MARINE ENGINEERING.

Vol. 5. NEW YORK, SEPTEMBER, 1900. No. 9

PASSENGER AND FREIGHT STEAMER, "HARTFORD," BUILT FOR THE NEW YORK AND HARTFORD TRANSPORTATION CO.

The steamer *Hartford*, built for the New York & Hartford Transportation Company, by the Columbian Iron Works of Baltimore, and now in use carrying passengers and packet freight between New York and Hartford, is a twin screw steel vessel of 1,488 gross registered tons, and having a cargo capacity of about 300 tons of ordinary freight and accommodations for from 250 to 350 passengers. Sleeping accommodations for the former number are provided, but the navigation rules allow as a maximum 350 passengers to be carried on account of the excellent equipment for protection against fire or accident.

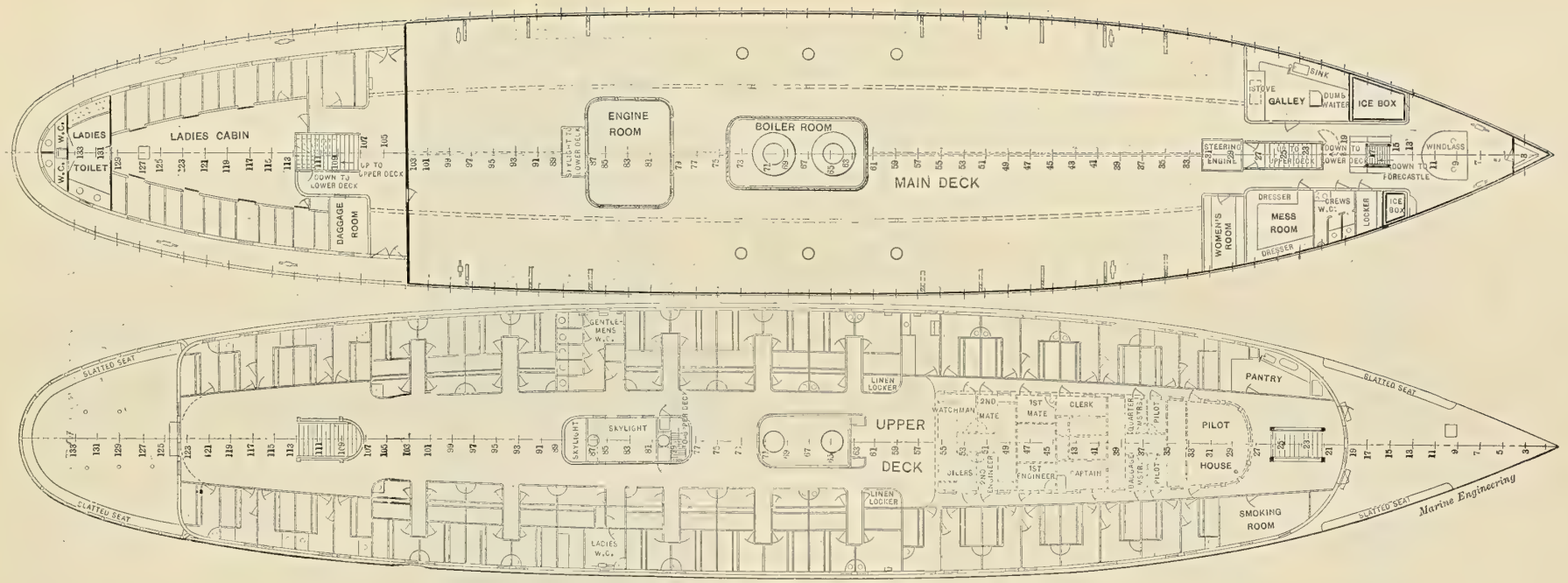
STEAMER HARTFORD, OF THE NEW YORK AND HARTFORD TRANSPORTATION CO.

The vessel is 253 ft. long over all, with moulded beam of 40 ft., beam inside of fenders 45 ft., beam at load water line 37 ft. 6 in., depth at side 13 ft. 3 in., and mean draft of 8 ft. The lower deck is used for freight cargo, and also for crew accommodations. Upon the main deck are the grand saloon, the dining saloon, the social hall, and 64 staterooms. The pilot house and the captain's and other officers' quarters are on the upper deck. Upon this deck also is a promenade, partially covered by an awning when necessary. Lifeboats, water buckets, and hose are also carried on this deck. The ship's main galley is also located on the upper deck, and is connected with the distributing galley on the main deck by an elevator for carrying the eatables to the dining saloon. The complement of officers and men consists of captain, 2 pilots, 2 mates, 1st and 2d engineers, 3 watchmen and 55 crew. The accommodations for passengers are commodious and well arranged, and the service on the boat is excellent.

Electric light is supplied by 250 16 C. P. incandescent lamps, of which those in the engine and boiler compartments have vapor proof globes. A 6,000 C. P. searchlight, of Carlisle & Finch's make, is also fitted, together with electric side and headlights.

When in the river the steering is done by watching the shore rather than by compass, and in case of fog it is found that the glare of the headlight renders it impossible to see the shores of the river, and that navigation is thus made very difficult. To provide for

(Copyright, 1900, by Aldrich & Donaldson, New York.)



GENERAL ARRANGEMENT AND ACCOMMODATION PLANS OF STEAMER HARTFORD.

such conditions the headlight is so arranged that it may be cut out of the circuit by the officer on the bridge or from the pilot house.

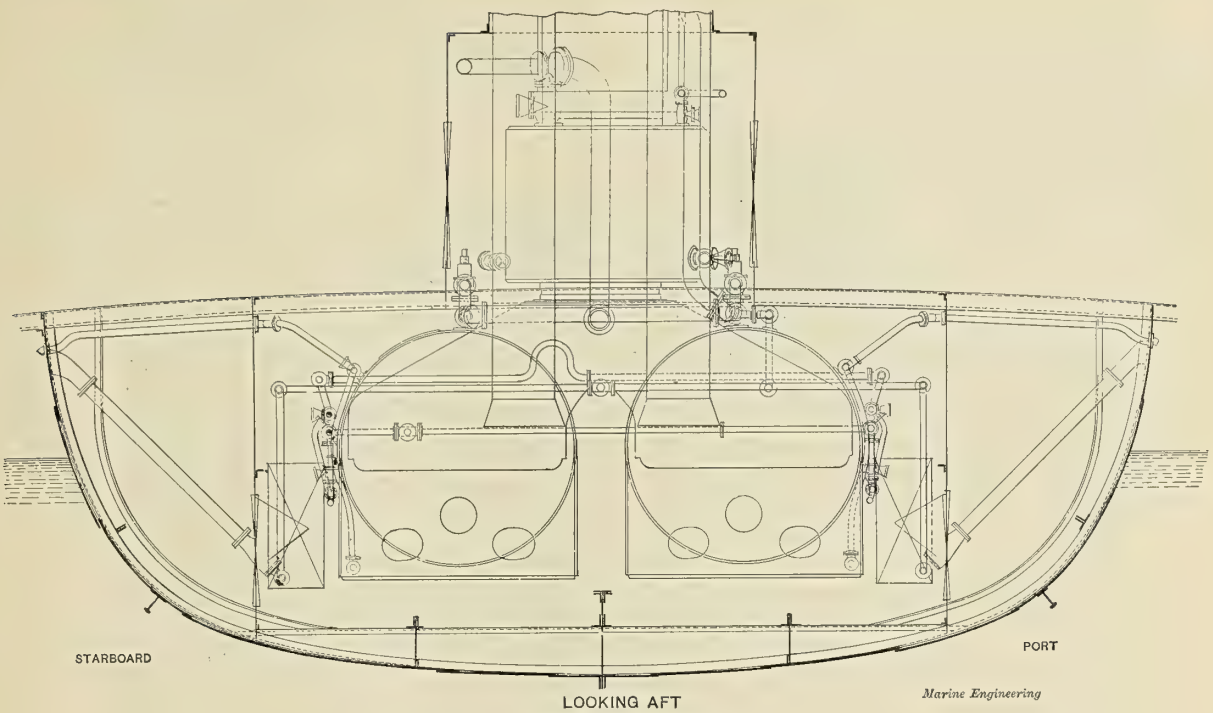
The incandescent lights are divided into twenty-five circuits of ten lights each, each circuit having a separate fuse at the switchboard in the engine room, so that the engineer can replace a burnt out fuse without leaving his station. The current is supplied to the electric lights by a 15 K. W. generating set located between the main engine shafts at the after end of the lower engine room. The dynamo is of the Eddy type, and is run by a "New York safety" engine.

On the lower deck is a Hyde steam windlass for hoisting the anchors and for operating the capstans on the upper deck. The steering engine is placed on the lower deck directly beneath the pilot house and the operating shaft leads from the engine up to the trickstand in the pilot house, while in addition to the steam steering gear there is a large wooden hand-wheel and wire rope drum located just aft of the trickstand for use in case of accident to the steam gear.

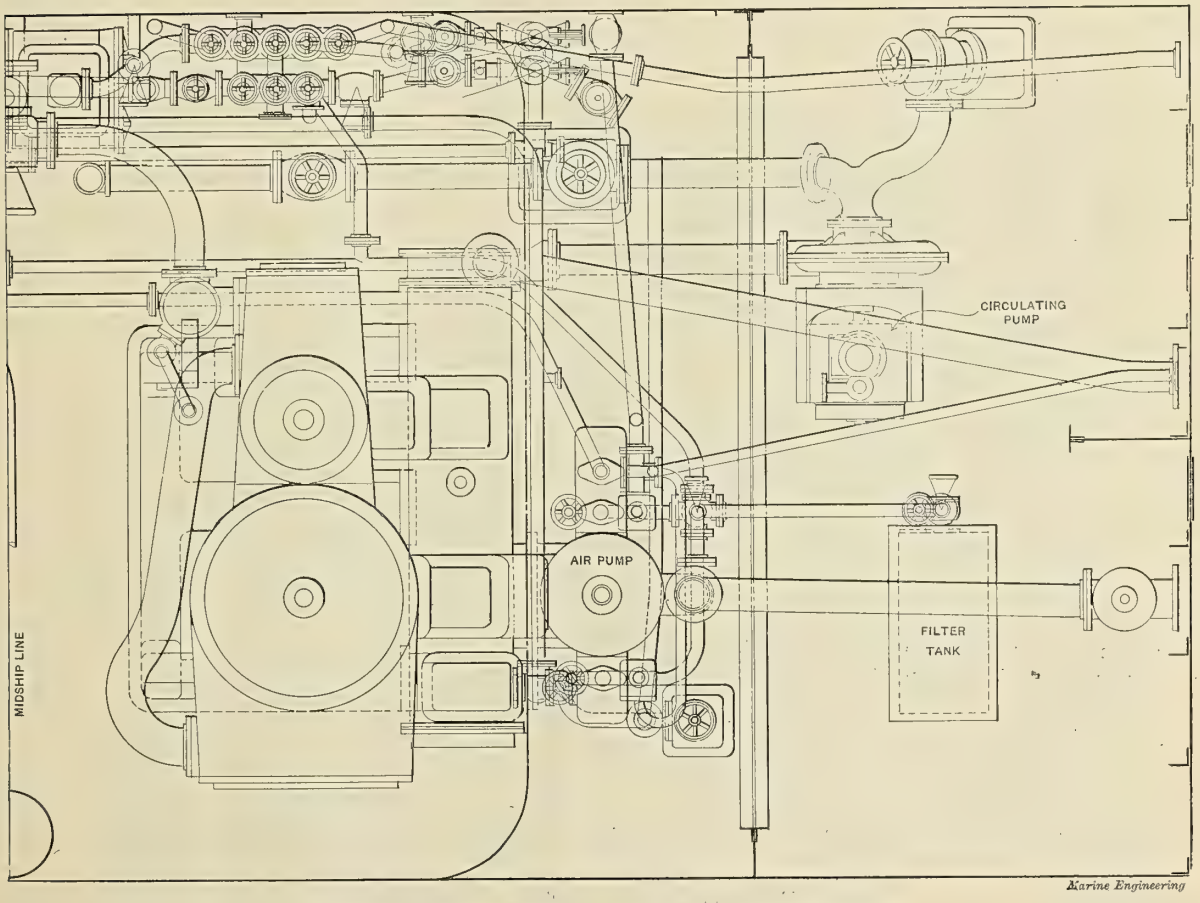
The vessel is propelled by twin screws, driven by two compound vertical condensing engines, having cylinders 20 in. and 40 in. dia. by 28 in. stroke. The high pressure cylinders are placed forward. The main steam pipe from the boilers is 8 1-2 in. dia., of copper, and branches into two 6 in. pipes leading to the throttle valves. The valve gear is of the ordinary Stephenson link type, the high pressure valve being arranged with a Meyer cut-off. The eccentric rods are of forged steel, and have bolt and nut ends. The crosshead guides are of rectangular box section. The upper ends of the connecting rods are forked, and work on forged steel crossheads. Both the upper and lower ends of the rods are fitted with strap connections. The crank shaft is 8 in. dia., forged steel throughout, of the built-up type, with crank pins 8 in. dia. The reverse shafts are on the inboard sides of the engines and are supported by the front columns which are cast iron of rectangular box section. The reverse engines and the handling gear are on the forward inboard column of each engine, the handling gear quadrant supporting also the throttle and reverse gear handles.

At the after end of the engine a worm wheel and worm are fitted for turning the engine over by hand for repairs. Brass pipes for water service are fitted to each main journal and crank pin, and to the crosshead guides. The thrust block is bolted to a continuation of the engine foundation, but not directly to the engine bed plate casting. There are six thrust collars of the ordinary horseshoe type. The line shafting is supported by three spring-bearings.

The condensers are built into the back framing of



SECTIONAL PLAN THROUGH BOILER ROOM.



GENERAL ARRANGEMENT PLAN—STARBOARD ENGINE ROOM.

the engines, and extend the whole length of the bed plate. The condensing water is supplied by a 6 in. centrifugal pump located back of each condenser. The cooling water enters the lower section of the condenser and is ejected from the upper section. The fire pump is located at the forward end of the engine room in the center of the vessel. The air pumps are worked off the low pressure crosshead, together with two feed pumps and a bilge pump for each engine. These four pumps are all bolted to the back of the condenser. The feed water passes through the filter tanks, one on each side of the engine room back of the engine, sponges being used as filtering material. Besides the pumps already mentioned, there is a small sanitary pump in the engine room for supplying water to the various parts of the ship. The water for cooling the bearings is taken out of the water ends of the condensers.

The gratings in the engine room are of wrought iron, having spills 5-8 in. dia, and wrought iron stanchions. Brass pipe is used for hand rails. There are two 24 in. ventilators in the engine room. Over each engine is a 6 in. by 1 in. steel beam, carrying a traveling hoist for lifting parts of the engine.

The boilers are four in number of the water leg type, and are placed with axes fore and aft. The working pressure is 110 lbs. per sq. in. The shells are 8 ft. 6 in. dia. by 14 ft. long. The tubes are 3 1-2 in. dia. by 10 ft. 6 1-4 in. long, No. 11 B. W. G. There are two furnaces to each boiler. The water gauges for the after boilers are in the engine room, those for the forward boilers being in the boiler room. There is also a vertical donkey boiler 40 in. dia. placed on the main deck. There are two 27 in. ventilators in the fireroom. There are two stacks each 4 ft. 2 in. in diameter and about 56 ft. in height above the grates.

When the vessel is in the Sound, the feed water is taken from the hot well and fed into the boilers by the feed pumps. When fresh water is reached in the river, however, feeding is done by injectors which keep the temperature of the feed water satisfactorily high, and the air pumps are allowed to discharge overboard. An ash ejctor is fitted on each side of the fireroom supplied with water from the fire pump at 100 lbs. pressure.

Special attention has been given by the builders to the lighting and ventilation of the fireroom and engine room, with the result that in service these compartments are very comfortable. It is partly due to this that the full steam pressure is readily maintained under maximum conditions.

The coal supply is carried in wing bunkers at the ends of the fireroom, having a capacity of 100 tons. The boat is operated under natural draft, although there is provision for a steam jet in the stack. The average working pressure is 95 to 100 lb., and the engines turn at about 110 revolutions per minute with this pressure and 26 in. vacuum. The horse power of the two engines is about 1,000, and the speed of the vessel through the sound averages about fourteen miles per hour.

The first steamboat to navigate the western rivers was the *New Orleans*, built in Pittsburg in 1811, four years after the *Clearmont* had made her successful trial on the Hudson.

EQUIPMENT FOR HANDLING BULK CARGOES RAPIDLY AT GREAT LAKE PORTS.*—III.

BY ARTHUR C. JOHNSON.

The Brown Hoisting and Conveying Machine Co. has built five car dumpers that handle the coal still more gently, but on that account they are necessarily slower in operations. With these machines the coal is dumped from the cars into six buckets carried in a transfer car. Each of these buckets is then lifted by either of two traveling cranes which carries it out over the boat and lowers it into the hatch when the bottom is opened and the bucket drawn away, thus placing the coal very gently and just where wanted. The mechanical arrangements are very ingenious and well executed in securing the complicated motions necessary.

The Hulett Car dumper built by the Webster, Camp and Lane Machine Company, for the Rochester and Pittsburg Coal and Iron Company at Buffalo, works somewhat on the principle of the Brown car dumper, but it is much simplified by using only two buckets—in fact the whole machine is comparatively simple. The clamping mechanism is of the same type as that of the McMyler Machine. The engines for tipping the cradle are located underneath the same, while those for controlling the buckets are located on the platform on top of the machine. The tracks on which the trolleys carrying the buckets run can both be swiveled about a pivotal point by hand to suit any spacing of hatches. The machine can handle regularly 20 cars an hour, but the switching room at Buffalo is so limited that a sufficient supply of cars cannot readily be made accessible to the machine.

A novel design of car dumper is shown in Figs. 17 and 18, built by the Excelsior Iron Works Company for the Erie Coal Transfer Company at Cleveland. This is an exceedingly fast machine, and its operation is very simple. The loaded car is pushed into the cylinder by a locomotive, and the cylinder and car are turned over by a steam cylinder of long stroke, operating through a "two part" rope. The car is supported on its side in turning over by a hydraulic cylinder and clamped on top by a simple device. The machine is well adapted to its peculiar location, where the bank of the river is very high, but the fall of the coal is considerable.

In all the car dumpers the speed depends largely on the switching arrangements and the storage capacity for loaded and empty cars. The three methods in use for bringing the loaded cars into the machine are: 1st. By means of a locomotive. 2nd. By storing the loaded cars on tracks having a down grade into the machine. 3rd. By the use of a haulage mule similar to that shown in Fig. 19. In the last case there is a grade up into the machine. The loaded car pushes the empty car out in all cases.

The car dumpers are also used for fueling vessels, although some of the fuel hatches cannot be reached by the chutes, but most docks handling fuel alone are

---

*A paper read before the Civil Engineers' Club of Cleveland and contained in the Journal of the Association of Engineer Societies.

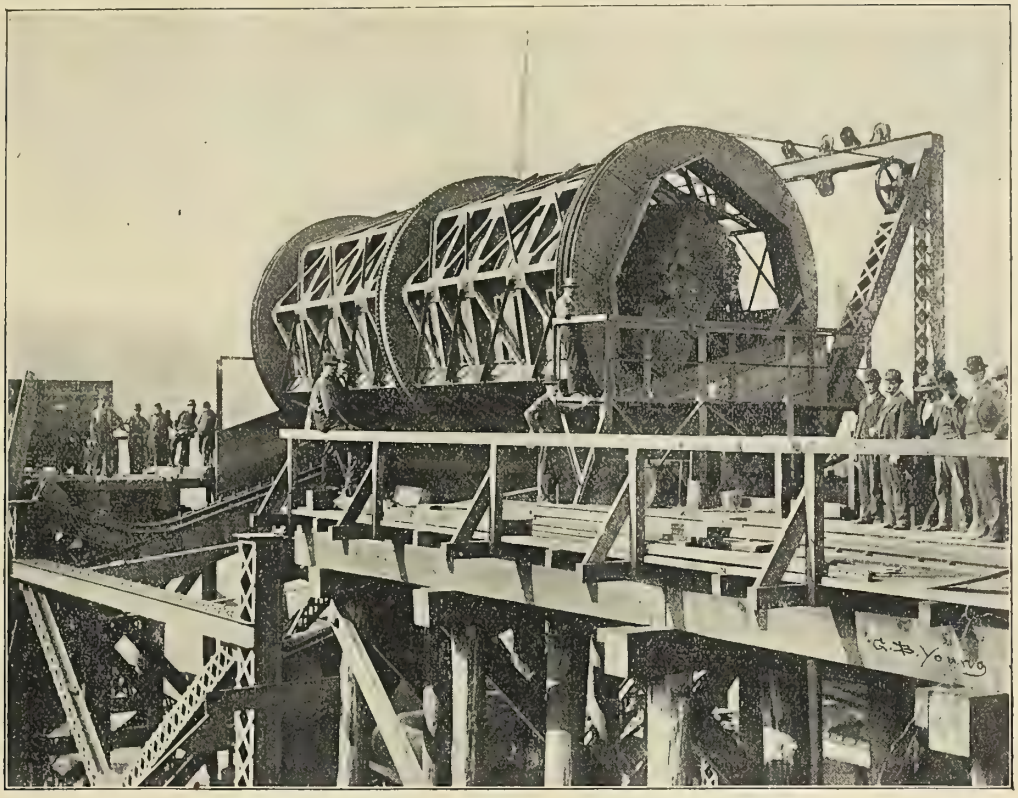


FIG. 17. CAR DUMPER BUILT BY THE EXCELSIOR IRON WORKS CO.

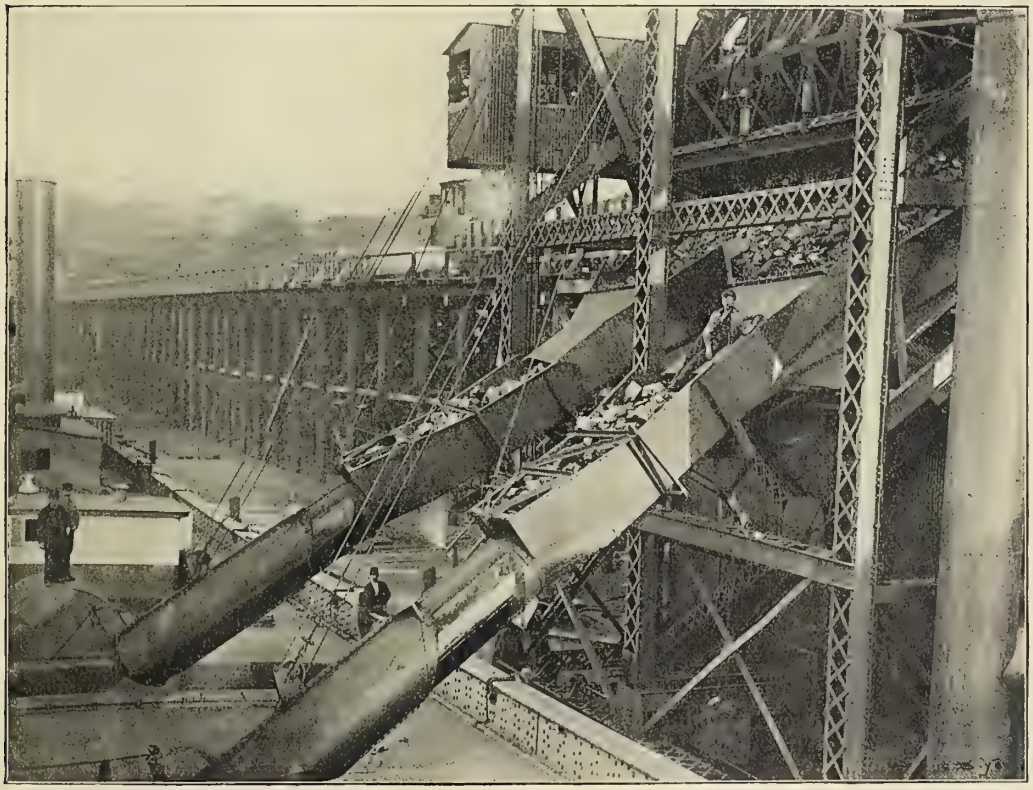


FIG. 18. CAR DUMPER BUILT BY THE EXCELSIOR IRON WORKS CO.

equipped with coal pockets at a sufficient elevation to discharge the coal through chutes into the coal bunkers, the pockets themselves being filled by drop bottom cars from a track carried on top. Fig. 19 shows the equipment of a large fueling dock operated by the Cuddy-Mullen Coal Company at Cleveland, built

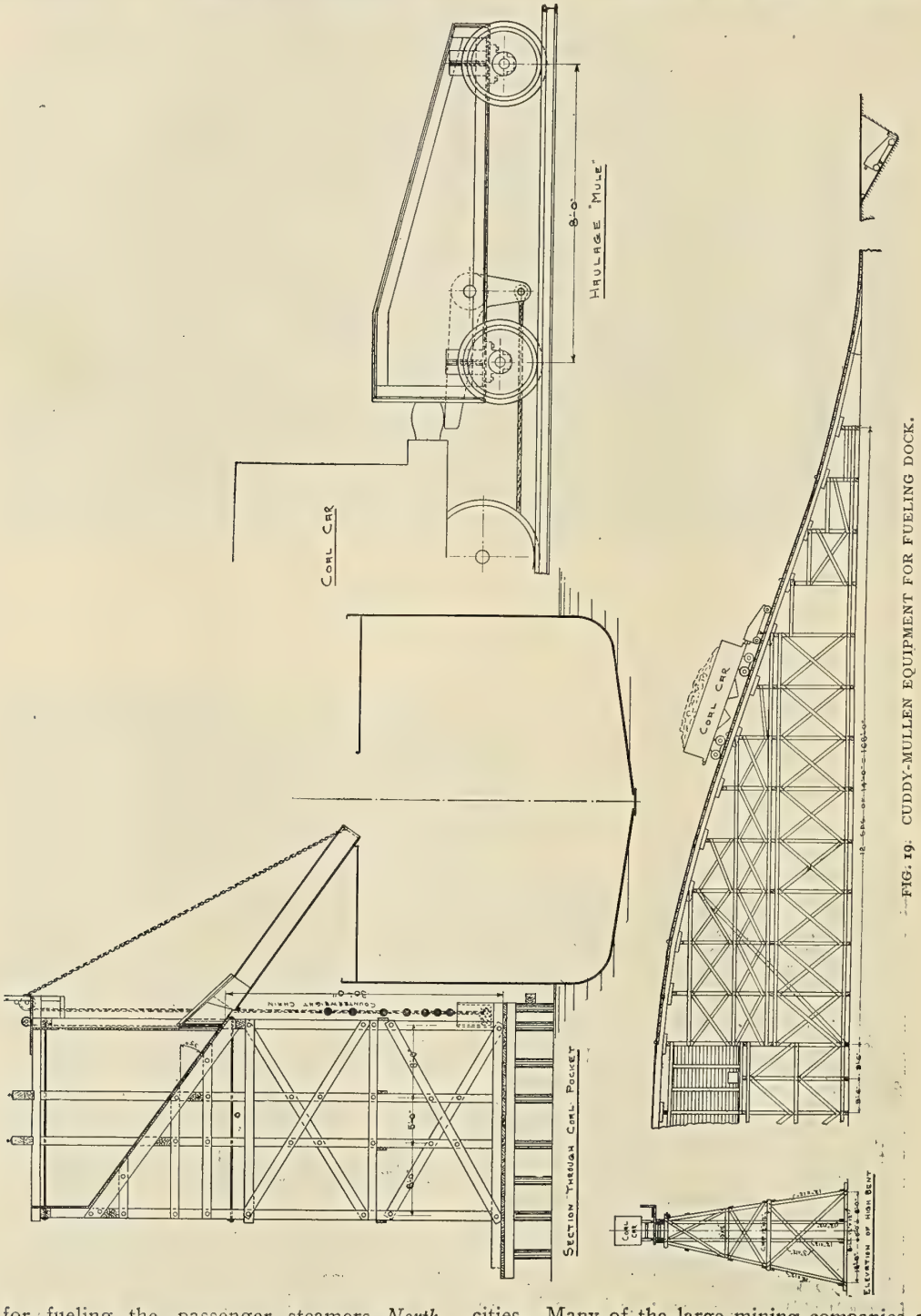


FIG. 19. CUDDY-MULLEN EQUIPMENT FOR FUELING DOCK.

specially for fueling the passenger steamers *North West* and *North Land*. The chutes in this case are round in order to enclose the dust. The method of hauling the coal cars up the steep grade is shown—also the ingenious method of holding the mule down to its track, thus preventing it from climbing due to the friction between the coupler and the front of the mule.

For unloading coal at the Northern ports there are many special machines of the Brown type and others adapted to the special conditions such as storage for railroad re-shipment and wagon delivery in large cities. Many of the large mining companies also have extensive coal storage docks to tide them over the four months of closed navigation.

A notable storage plant is that of the Lehigh Valley Coal Company at West Superior, Wis., on which there is storage capacity for 100,000 tons of anthracite

coal under cover by the Dodge system, and for 90,000 tons of bituminous coal exposed, in piles not over 30 ft. high as precaution against spontaneous combustion. At this plant all the operations of unloading from the boats and storing, and reloading into the cars are performed by machinery.

The most surprising feature in connection with the equipment of docks generally on the lakes—using the word dock in the American sense of pier or landing

great improvements in this direction and as examples of recent construction Figs. 20 and 21 are introduced. Fig. 20 is the cross section of a dock built by the Illinois Steel Company at their South Chicago works, which has attracted a great deal of attention from engineers in this country. This dock, which is 1,608 ft. long, was built at the rate of about 15 ft. per day. Fig. 21 is a cross section through the foundation for the McMyler car dumper on the dock of the Pittsburg and

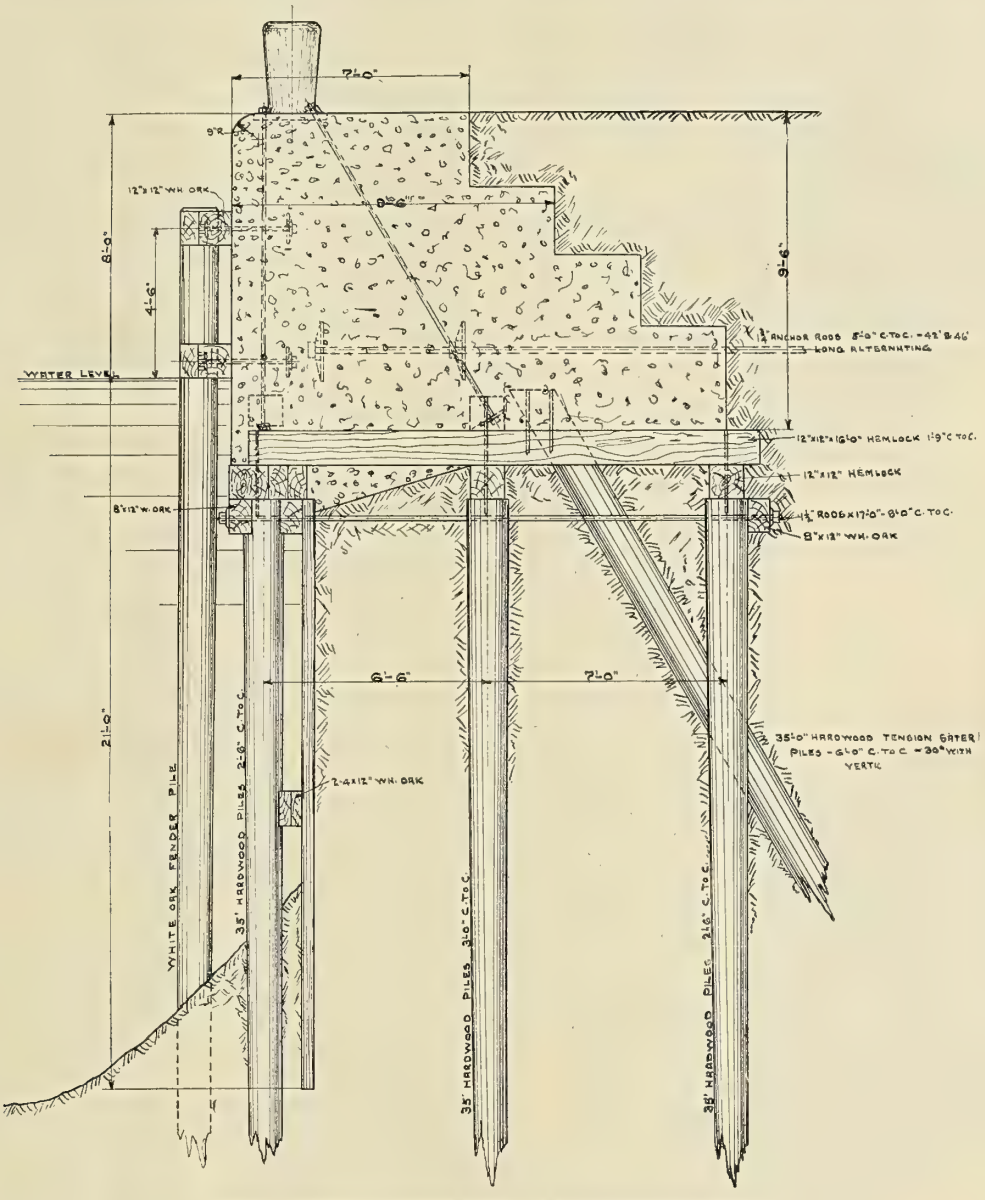

7'-0"
9'-6"
12"x12" WH. OAK
8'-0"
4'-6"
WATER LEVEL
1¼" ANCHOR RODS 5'-0" C. TO C. - 42' 8" LONG ALTERNATING
12"x12"x16'-0" HEMLOCK 1'-9" C. TO C.
12"x12" HEMLOCK
1¼" RODS X 17'-0" - 8'-0" C. TO C.
8"x12" WH. OAK
8"x12" W. OAK
6'-6"
7'-0"
21'-0"
35'-0" HARDWOOD TENSION GIRDER PILES - 6'-0" C. TO C. - 30° WITH VERTICAL
2-4x12" WH. OAK
WHITE OAK FENDER PILE
35' HARDWOOD PILES 2'-6" C. TO C.
35' HARDWOOD PILES 3'-0" C. TO C.
35' HARDWOOD PILES 2'-6" C. TO C.

FIG. 20. SECTION OF DOCK BUILT BY THE ILLINOIS STEEL CO.

to which a boat ties—is that such highly improved and expensive machinery should be placed on such poor and entirely inadequate foundations; often merely a few piles, driven in soft mud many feet below the water line, with little or no cross bracing to give them some rigidity. This is probably due to the nervous speed with which a great many dock improvements and extensions have been made.

There is a growing feeling, however, in favor of Conneaut Co., at Conneaut, Ohio. This foundation has proved itself to be immovable.

It will be of interest here to quote from the *Blue Book of American Shipping* that on the Great Lakes there are "The greatest iron mining resources, most rapid cargo handling facilities and the most efficient iron producing plants in the world," together with the statement that "It is possible to take ore from the Mountain Iron Mine and convert into steel ship

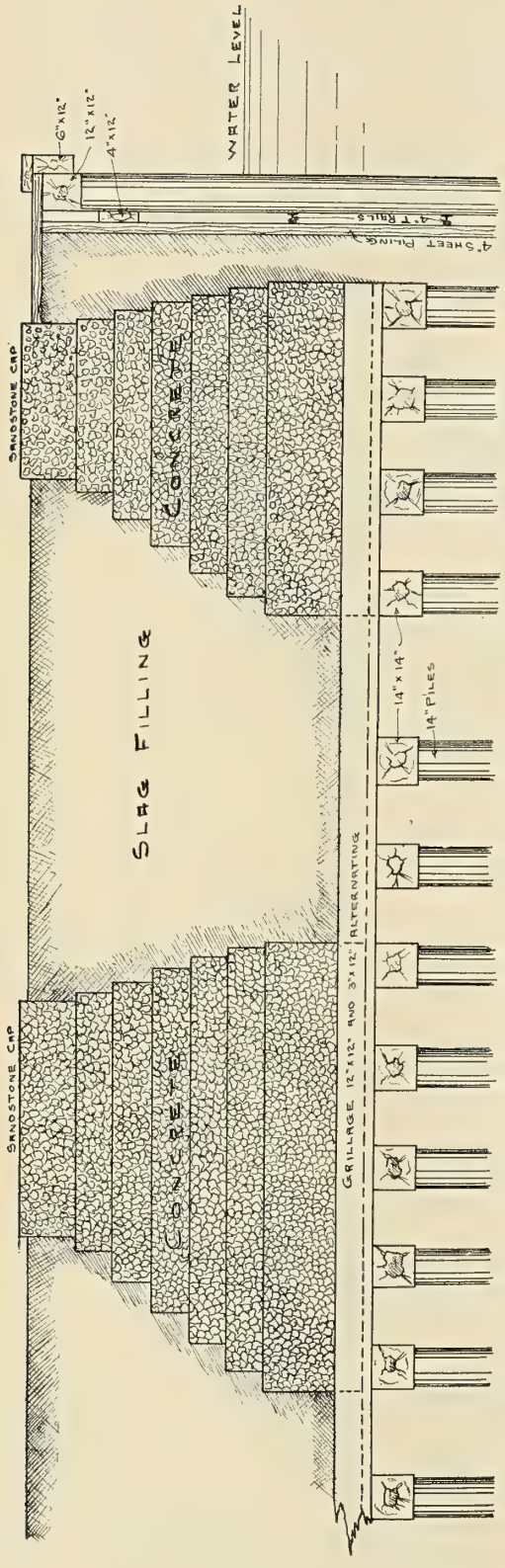


FIG. 21. SECTION THROUGH FOUNDATION FOR McMYLER CAR DUMPER.

plate within ten days." While not becoming responsible for the accuracy of the last statement, quoting from the same source, the explanation is as follows:

"Suppose that on the first day and night of a month 9,000 tons were mined and loaded. The second day at noon this ore could be run onto the Duluth, Mesaba and Northern Railway docks at Duluth, 80 miles from the mine and dumped into pockets. Each of the two docks lack 600 ft. of being 1-2 mile long, and both have capacity for 100,000 tons of ore. In one hour the 9,000 tons could be loaded into a Bessemer steamer and barge, 424 and 366 ft. long respectively. The Bessemer fleet consists of ten steamers and eleven barges, and the carrying capacity of the fleet for one season, between eight and nine months, is over 1,500,000 tons. At one o'clock on the second day the steamer and consort would start on their 890 mile trip. On the sixth day at one o'clock they would arrive at Conneaut, Ohio, the steamer, we will say, going to the McMyler rapid direct-unloading plant and the consort to the Brown plant, both of which are shown in the foregoing illustrations. The seventh day at one o'clock the 9,000 tons of ore would have been taken from the holds of the vessels and loaded into 180 of the 50 ton steel cars, of which the Pittsburg, Bessemer and Lake Erie has 600, and is building 400 more. On the morning of the eighth day these cars would be delivered to the furnace at Bessemer or Duquesne, the four-stack furnace, having annual capacity of 800,000 gross tons of pig iron, at the latter point. The distance from Conneaut to this furnace is about 150 miles.

"On the ninth day at seven o'clock in the morning the ore would have run through the cupola and could be transferred to the Bessemer converter or mixer, and in less than an hour he turned into steel ingots. These ingots could be taken hot to the plate mill and made into ship plate in one hour, or, if from the furnace the iron was made into pigs, about eight hours more would be required to make ingots of the pigs. By the evening of the ninth day this plate would be ready for shipment."

A recent circular from the U. S. Civil Service Commission announces that it is desired to establish an eligible register for the position of Master in the Quartermaster's Department at Large. No scholastic test will be given, but applicants will be graded upon the elements of age, experience, intelligence, character as a workman, and physical qualifications as shown by the information furnished in connection with their formal applications. Candidates may be assured that the ratings will be strictly impartial and based entirely upon the evidence of fitness presented. It will not be necessary for applicants to appear at any place for examination. From the eligibles resulting from this examination certifications will be made to the position of master on the Quartermaster's steamer *General Ayres* at Boston, Mass., at a salary of $110 per month. Persons who desire to compete should at once apply to the secretary of the local board of examiners at Boston, Mass., or to the United States Civil Service Commission, prior to the hour of closing business on October 1.

MATERIALS USED IN THE CONSTRUCTION OF MARINE DYNAMOS AND THEIR ENGINES.

BY ALTON D. ADAMS.

High efficiency, satisfactory operating qualities and reliability are prime requirements for marine dynamos and their engines. Next to these, the most essential characteristics of engines and dynamos for use on ships are small bulk and weight per unit of capacity. How pressing are these last named requirements may be gathered from the fact that in merchant ships a considerable, and in war ships an even larger, per cent of the displacement beyond that of the hull is taken up by the necessary operating machinery.

Almost the entire construction and equipment of ships, except the electric plants, has been the subject of long study and careful experiment, to determine the materials best suited for the purpose, and no reasonable expense has been spared in high class war and merchant vessels to produce the best possible results. In the past it has been the more common practice, on the part of both private ship builders and governments, to accept about what has been offered by dynamo and engine makers, so far as weight and bulk per unit of output are concerned. It is true that some restrictions have been put to the weights of electric generating sets, but these have only been such, in most cases, as good apparatus made for use on land could meet. The growing importance of electric equipment on ships and its application to auxiliary power purposes seems certain to result in more exacting requirements as to weight and bulk.

Good design is able to meet the usual conditions as to efficiency, operating qualities and reliability in dynamos and engines with the structural materials and shapes generally employed, but when bulk and weights are restricted, the kinds and shapes of the materials used are at once involved. The reason for this is found in the fact that structural materials for both engines and dynamos differ widely among themselves in their most important qualities. The characteristics of dynamo materials that have the most important influence on weight and bulk are those of magnetic and electric properties and mechanical strength. Most important of these properties is the magnetic, because of the wide variation among the available materials in this respect, and its large influence on the requirements as to mechanical strength and electrical factors. In the largest and heaviest parts of a dynamo the dimensions necessary to secure desirable magnetic qualities are much in excess of those required for mechanical strength, even where the best available materials are used. It is therefore highly important, where small weight and bulk are necessary, that the magnetic and electric parts of dynamos be of the most suitable materials.

To determine what materials are best suited for use in the several parts of dynamos, the purpose and action of each part should be considered. Taking up first the armature or revolving part, complete, it is found to consist of four essential elements, the shaft, core, windings and commutator. An armature shaft may be forged in one piece with that of its connected engine, but is more usually connected by couplings. In either case there are no requirements to be made as to its magnetic or electric properties, the main necessity being for mechanical strength and stiffness. To insure the desired mechanical properties in a dynamo shaft of the least practicable weight, its material and form should be minutely specified. Dynamo shafts should be forged of hard steel, having about 0.5 per cent of carbon, and should be hollow, as hollow shafts are much lighter than solid ones for given length, dimensions and strength. The largest and heaviest part of an armature is its core, which in practically all cases is built up of wrought iron or very mild steel discs, either of which are suitable for the purposes of light weight when of the proper quality. Armature cores are especially designed to meet magnetic requirements, and their mechanical strength is commonly far beyond any possible demands upon it. Magnetic properties of their iron or steel discs, and the construction of armature cores as to ventilation, materially affect their weights for given capacities, but it is hard to cover these factors save by specifications of the total armature or dynamo weight.

To hold the armature core together and enable it to be assembled independent of the shaft, the discs are mounted on a spider or sleeve and this latter adapted to slide on and off the shaft. This sleeve or spider usually has an extension beyond the armature core at one end and on this extension the commutator is mounted. No electrical or magnetic properties are necessary in the spider, and its important qualities are sufficient strength and stiffness for its work. Cast iron is much used for armature spiders, because it is so readily obtained and easy to machine, but its low strength to resist twisting and shearing make it unfit for the purpose. where small weight per unit of output, for the armature, is desired.

The best material to use for armature sleeves and spiders, for marine use, is soft steel castings, such as can now be had from a large number of foundries. About the only objections to be urged against steel castings for the purpose just named are their somewhat higher first cost both as to the price per pound and the labor for machining them. The additional cost per pound of steel castings is, however, about offset by their smaller weight.

A dynamo commutator consists broadly of two distinct parts, the shell or sleeve and the segments. The shell acts simply as a clamp to hold the segments together, and is usually made of cast iron. When the reduction of weight is an object the commutator shell should be of steel castings, as these give the required strength and stiffness with the least weight. Pure forged or rolled copper is the best and only fit substance for commutator segments, in spite of claims to the contrary by any who wish to sell cheap segments or dynamos with poor commutators. Cast segments are hard to produce in chemically pure copper, their electric conductivity is lower than that of the forged or rolled variety, and they do not resist the wear of the brushes as well. For equal results in operation the cast copper segments make a heavier commutator than forged or rolled stock, and they should never be used on ship dynamos.

Poor ventilation or bad proportions may result in an armature core too heavy for its capacity, and such a core increases the necessary weight of copper wire for winding it. Copper in rods or wire is the only suitable material for armature windings, and those windings

with joints at only the commutator end should be preferred to those having joints at both ends. Some armature cores have a large extension at one end to act as a support for the windings, but this is unnecessary and should be avoided. The magnet cores and poles of dynamos, that is, those parts on which the magnet coils are mounted, form large and very important portions of the machines.

Magnetic properties are chiefly considered in the size and proportions of magnet cores and poles, their mechanical strength usually being far beyond any possible requirements. So great are the differences between materials as to their magnetic properties, that the weight of magnet cores may vary as much as three or four hundred per cent according to the materials selected. Cast iron, wrought iron and steel castings are the materials available for magnet cores and poles. The widely different results as to weight that follow the use of these several metals for magnet cores arise from their different magnetic capacities per unit of sectional area. If the magnetic capacity of wrought iron is taken as unity, per square inch, that of cast iron is about .4, and of steel castings from .8 to 1. In other words, if a wrought iron magnet core with a sectional area of 100 sq. in. will do the work for a certain case, a core of equal capacity of cast iron must have 250 sq. in. and a core of steel casting from 100 to 125 sq. in. sectional area. The length of magnet cores is determined by the amount of wire and energy used in their coils, an increase in the areas of cores increases also the wire necessary for their windings, and usually therefore the length of each core. For the case of cast iron compared with wrought iron, the cast metal being 2.5 times as large in section, and probably 1.5 times as long, at least, is $2.5 \times 1.5 = 3.75$ times as great in bulk and nearly that in weight. Where steel castings are used for magnet cores the increase in weight over that for wrought iron, if any, is obviously small. Great as is the addition of weight by the use of cast iron for magnet cores, it is further augmented by the larger amount of wire necessary for windings. Cast iron was much used at one time for magnet cores, but now steel castings and wrought iron are generally used for the purpose, and should be specified in every case.

The magnet frame or part that serves to mount the magnet cores about an armature, being the largest and frequently the heaviest single part, should be carefully selected, where the reduction of weight is an object. While cast iron magnet cores have been largely abandoned, the cast iron frame is still very common. The purpose of a magnet frame is two-fold, that to mount the magnet cores and fix them to the base and also to furnish magnetic paths between the several cores. Owing to the attractions between the magnet poles and their armature the frame is subject to large mechanical strains, but its section at any point is determined in most cases by the magnetic requirements. In cases where the necessary magnetic capacity can be had with a very small frame section, an excess of mechanical strength and stiffness can be obtained by giving the frame a ribbed or flanged form. Where the weight per unit of output is not material, the use of cast iron for magnet frames may be permitted, but for marine dynamos all frames should be of steel castings, except for some simple shapes where wrought iron is available.

However carefully a dynamo may have been designed to reduce its weight, it has been the too general custom to give an iron foundry a large job on the common base for a dynamo and connected engine. The fact of course is that unnecessary weight in a base is just as objectionable as though it existed in the dynamo proper. A dynamo base is not usually required to have any magnetic properties, but must be stiff and strong. Steel castings are much the most suitable material for dynamo bases where small weight is desired, and should be used to the exclusion of cast iron for this purpose in marine work. The saving in weight by a steel casting instead of a cast iron base is often enough to compensate for the greater cost of the steel.

To rest with restrictions on the weight and materials of dynamos only, for an electric plant on board ship, is to leave the work of specification but one-half done, since the ordinary engine for use on land is even less satisfactory in the matter of weight than is the average dynamo. Vertical engines are the general type best suited for driving ship dynamos, because of the small floor space occupied, the ease of making direct connection to the dynamo, and the high speeds of rotation at which they may be operated. In land engines, and to a large extent those for electric plants on ships, cast iron has long been the most prominent material. Cylinders, piston heads, guides, frames and bases have all found in cast iron their most convenient material. Crank shafts even, in some instances, have been built of much the same material, that is, gun iron, which is simply cast iron of a somewhat higher grade and an increase of strength above the ordinary metal.

Crank shafts for dynamo engines should be forged of hard steel and hollow. In sizes too small to allow hollow forging, the shaft may be forged solid and the interior parts subsequently machined out. Connecting rods should also be of hard steel, but instead of the regular tapered forms rods should be machined into some of the shapes that give required strength with a minimum weight of metal. Hollow piston rods are to be preferred to solid ones in large sizes. Steel castings offer a material saving over cast iron for piston heads and cylinders, in the matter of weight, owing to the strength required in these parts. Cast iron engine frames have in many cases heretofore made up a great part of their weights, as used for driving ship dynamos, and it is in this part of the construction that considerable improvement is possible. A number of vertical engines that have been much used for driving marine dynamos are of what is known as the enclosed type, with hollow cast iron frames that connect cylinders and bases. Such an engine is necessarily heavy per unit of capacity. Other engines have a cast iron frame between the cylinders and base at one side, and a solid steel rod or rods at the other side, but these engines must also be discarded as too heavy.

The nearest approach to a really suitable engine for ship dynamos that is found among present standard types is put out by several makers with four or more solid steel standards to connect the cylinders and the base. This last named type of engine is capable of production in very low weights, when parts other than the standards are made of the most suitable materials. Some engines on the market, however, in imitation of the steel rod construction between the cylinders and

base, have used standards of cast iron for the purpose. An engine with these cast iron standards is unnecessarily heavy, and is apt to be fatally weak in its frame. The most desirable construction for light weight in that part of the engine frame between cylinders and base consists of hollow steel standards.

Instead of cast iron, the bases of engines for ship dynamos should be of steel castings, because of the large reduction in weight for given strength and stiffness effected by the use of this metal. About the only parts of engines for electric plants on board ship that may rationally be of cast iron are the piston rings and perhaps linings for the cylinders. By suitable designs with wrought steel and steel castings in engines and wrought iron, steel, and steel castings in dynamos, the weights per unit of capacity may readily be reduced as much as fifty per cent for engines and twenty-five per cent for dynamos, below those often found in ship electric plants.

A meeting of the Board of Life Saving Appliances was held at the Post Office building in Boston, June 6, 1900, at which were presented a number of appliances intended for use in the service. The most important matter was the application of power in life-boats—a question which has attracted much attention, especially in later years.

A 34 foot life-boat at Marquette has had a gasoline tank placed in the after air case under the direction of Lieut. McLellan, by the Lake Shore Iron Works of Marquette, Michigan, and the boat gives promise of great usefulness.

The board adopted resolutions recommending that a special commission be appointed by the Secretary of the Treasury to inquire into the question of the application of power to life-boats, and with authority to make tests on the boats before mentioned. Such a commission was appointed consisting of the following members: Prof. Cecil H. Peabody, President of the Board on Life Saving Appliances; Lieut. C. H. McLellan, R.C.S. Assist. Inspector L.S.S.; J. G. Kiah, Superintendent 11th L.S. District; H. M. Knowles, Superintendent 3rd L.S. District.

Two members of the commission, Prof. Peabody and Lieut. McLellan, have gone to Marquette to determine the nautical properties of the lifeboat at that station, such as the displacement, stability, center of gravity, and also the power and speed of the boat on a measured course. As a basis of comparison the properties of a similar boat without an engine will also be determined.

The advantage of power in a life-boat, so applied as not to interfere with the essential qualities, such as the ability to right and free herself from water if capsized are sufficiently evident at a glance, even if the power be considered as auxiliary, the boat still retaining sail and oars.

At Belmore, L. I., a novel craft in which the owner intends to cross the Atlantic is under construction. The boat is to be 58 ft. long and schooner rigged. She will have a high freeboard, and will draw only 2 ft. of water. Besides her sails she will carry a gasoline motor with good supply of fuel for use in calm or head winds.

TUG RICHARD CROKER, FOR DOCK DEPT., CITY OF NEW YORK.

A modern type of well equipped harbor tug is shown in the drawings of the *Richard Croker*, recently constructed for the Department of Docks and Ferries of New York city by the Gas Engine & Power Co., and Charles L. Seabury & Co. Consolidated, Morris Heights, N. Y. She is a steel vessel of the following dimensions: Length over all, 110 ft.; length between perpendiculars, 100 ft.; beam molded, 21 ft. 6 in.; depth molded, at mid length between perpendiculars, 12 ft. 0 1-2 in. Steel of a tensile strength of 55,000 lb. and an elongation in 8 in. of not less than 25 per cent. is the material used for the hull.

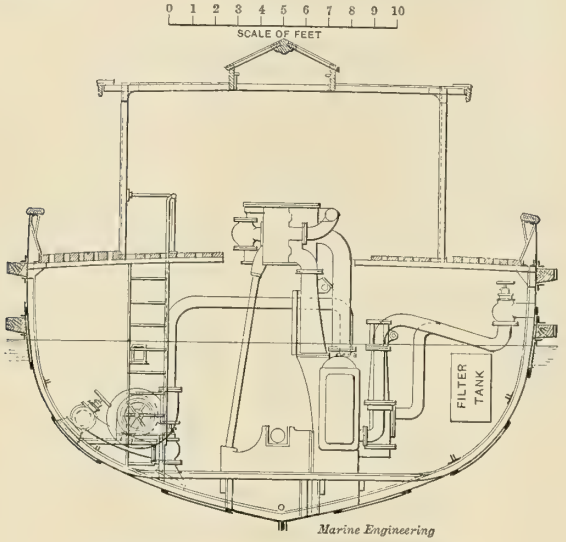
A solid iron bar keel 6 in. by 1 1-2 in. is fitted in lengths not less than 25 ft., with scarphs 18 in. long. The stem is also of iron, 6 1-2 in. by 1 1-2 in., rabbeted for the plating to about 3 ft. below the water line, and is scarphed to the keel. The stern frame and rudder post are forged in one piece of scrap iron, the main post being 5 1-2 in. by 2 in., counter connection, 5 1-2 in. by 3 1-2 in., rudder post 5 1-2 in. by 2 in., with the forward edge well rounded and with backing guards forged on. It is connected to the keel by a scarph 18 in. long. Frames are made of 2 1-2 in. by 2 1-2 in. by 5 lb. angles spaced 22 in. centers, and in one length from keel to top of frames. Scarph pieces of similar angles 3 ft. long are fitted across the line of the keel back of the floor plates, and are riveted back to back to every frame for one-half length of the vessel amidships. Frames at bulkheads are doubled. Reverse frames are 2 1-4 in. by 2 1-4 in. by 3.61 lb. angles. In the engines and boiler spaces these reverse frames are doubled to each floor plate and frame, one extending to the beams and the other to about 12 in. above the floor ends. Forward and aft of the machinery spaces there is one to each floor plate and frame, extending alternately to beams' end, about 12 in. above the ends of floor plates. Those extending to beam, butt at or near the middle line, and are connected by scarph pieces 20 in. long, and the others are in one piece.

Floor plates are in one length, on every frame, 28 in. deep in the engine space, 18 in. deep in the boiler compartment, and 12 in. deep forward and aft of these spaces. Under the engines they are 17.5 lb., under the boiler 15 lb., and forward and aft 12.5 lb. plates. The keelson is composed of two 3 in. by 3 in. by 7.4 lb. angles, riveted back to back. Main deck beams are of 3 in. by 3 in. by 7.25 lb. angles, worked with a crown of 3 in. in 21 1-2 ft. on every frame, and connected to frames by 10 lb. gusset plates, with 12 in. laps on frames and beams. The deck stringers are 3 ft. 10 in. wide and 10.5 lb. amidships, and reduced in width at the ends. The side stringers are two in number, of 3 in. by 2 1-2 in. by 6.53 lb. angles riveted back to back.

Transverse bulkheads are placed on frames 6, 18, 38, 48, and on frame 29 on the port side and 31 on the starboard side, forming the after ends to the coal bunkers. Longitudinal coal bunker bulkheads extend between the transverse bulkheads 18 to 29 on the port side, and 18 to 31 on the starboard side. All bulkhead plating is 7.5 lb. and is stiffened by 3 by 2 in. by 4 lb. angles. All bulkheads and doors are watertight.

For the outside plating, the garboard strake is 14

lb., the bilge strake 15 lb., and the shear strake 18 lb., the remaining strakes being 11 lb., except the bulwark strake, which is 10 lb. The plating is worked "in and out," single riveted, and at the butts double riveted. The tops of the sheer strakes are 5 1-2 in., and the bulwark strakes 22 in. above the tops of the beams at the sides. On each side there are three freeing ports 24 in. by 10 in. high, fitted with shutters. Gutters are formed by 2 1-4 in. by 2 1-2 in. by 5 lb. angles placed on top of the stringer plates, 8 in. inside of the plating.



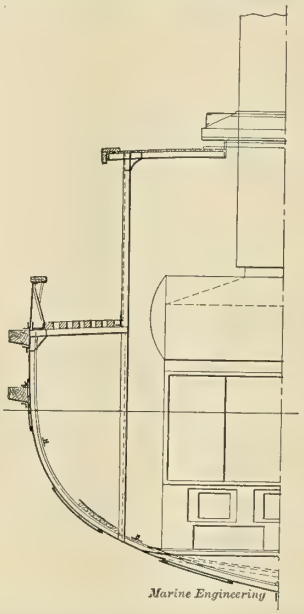
ENGINE ROOM OF TUG RICHARD CROKER.

White pine 3 in. square is laid on the main deck, and 2 in. square inside the house. The rail is of white oak 10 in. by 4 in., in lengths of about 20 ft., with 3 ft. scarphs fastened to the bulwark plating by 3 in. by 3 in. by 6 lb. angles. On top of the rail forward there are bow chocks of white oak 4 1-2 in. thick by 5 1-2 in. deep at the stern and reduced to 3 1-2 in. at the after ends. Aft the false rail is of the same dimensions. The upper fender is also of white oak 7 1-2 in. thick, and 8 in. deep, beveled to a 6 in. face, and running completely around the tug. The lower fenders on each side extend from the stem to about the after end of the house, and are of the same size as the upper, with a 5 1-2 in. face. Angles 3 1-2 by 2 1-2 by 6 lb., riveted to the plating by 3-4 in. rivets, extend along the tops and bottoms of the fenders, and the latter are bolted to the plating with 7-8 in. bolts. Both fenders are faced with iron straps 1-2 in. thick, secured by 6 in. countersunk spikes. On each side of the boat 10 swinging hickory fenders are hung, the main rail in the wake of the lanyards being protected by a covering of yellow metal 20 in. long and 15 in. wide.

Forward, the main bitts are 11 in. square white oak, with white oak cavil in two pieces 5 in. thick by 9 in. wide, securely bolted together, and they are stepped on top of the forward tank. Aft, the bitts are 14 in. square, and are stepped on top of the trimming tank. Rail bitts and nigger head forward are of cast iron, galvanized.

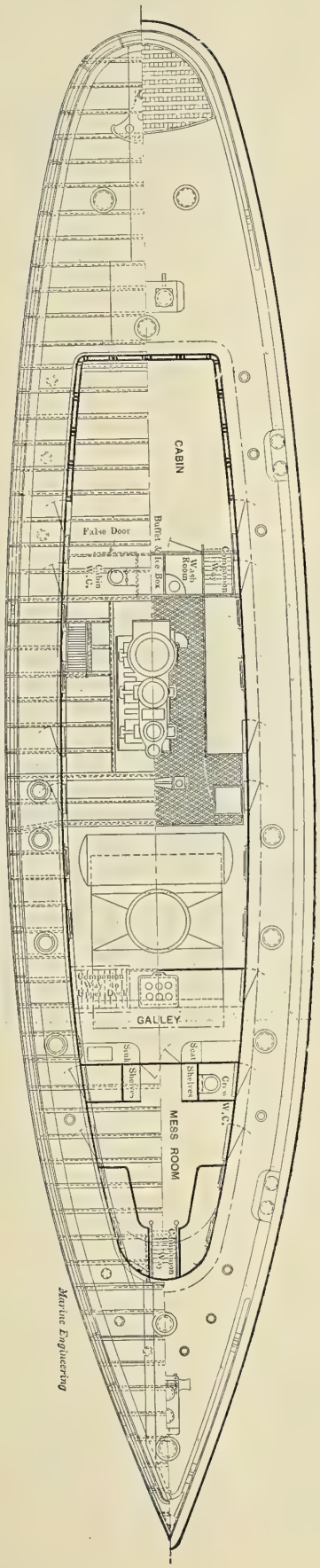
Steel is used for the deck house, which is about 66 ft. long and 13 ft. wide. The bottom coaming plates are 11 in. by 10 lb., connected to the deck plating and beams by 3 in. by 3 in. by 7.25 lb. angles. The top coaming plate is 8 in. by 10 lb., and the sides of the house are 8.5 lb. plate, stiffened by T-bars 2 in. by 4 in. by 5.5 lb. space 27 in. apart. Inside the house, at the forward end, a companionway leads to the sleeping quarters of the crew. The forward end of the house is occupied by the mess room, crew's water closet, and lockers. Aft of this is the galley, with regular range, sinks, etc., and from here a ladder leads up to the roof of the pilot house. The machinery spaces occupy the greater part of the deck house, extending to the after compartment, which is furnished as the cabin, with buffet, officers' water closet and wash room. On the port side of the cabin, a companionway leads down to the officers' sleeping quarters.

The house is tastefully furnished and equipped. Composition is used for the air port frames, and these are 20 in. diameter. In the mess room, below the line of seats, there are transom windows admitting light and air to the forecastle. Over the engine room and cabin there is a skylight about 21 ft. 6 in. by 4 ft. 6 in., made of oak, with ribbed glass, protected by polished brass rods in ash frames. The hinges are also of heavy brass, and the same metal is used for the quadrants at the top of the skylight. On top of the skylight, an 18 ft. metallic boat is carried in chocks, with davits which swing out, carrying the boat clear of the side. Polished cherry is used for the interior finish of the

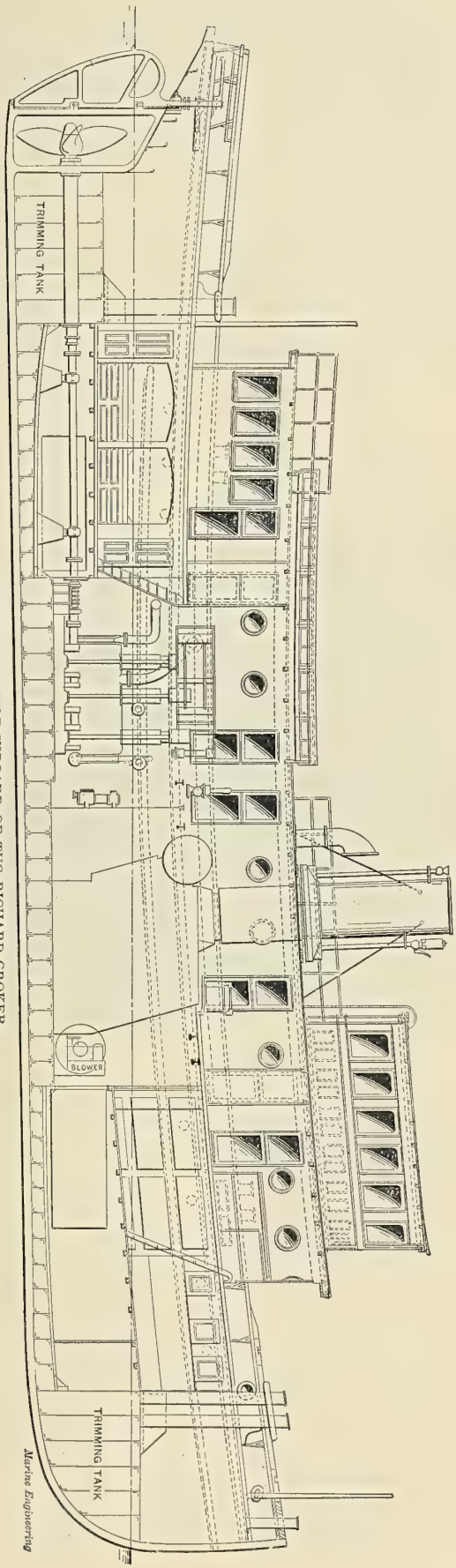


HALF SECTION THROUGH BOILER ROOM.

cabin, and the floor is laid with interlocking rubber tiling. Light and air in the cabin is provided by twelve drop windows 3 ft. high and 1 ft. 8 in. wide, four on each side and four in the end. In the lower after cabin there are four hardwood berths, with drawers underneath, and also clothes lockers and marble top washstand, with porcelain bowls and silver plated fittings. The decking on top of the house is white pine 1 1-8 in. by 3 in., tongued and grooved, and covered with No. 5 cotton canvas.



GENERAL ARRANGEMENT PLAN OF TUG RICHARD CROKER.



GENERAL PROFILE INBOARD OF TUG RICHARD CROKER.

On top of the deck house forward is the pilot house, 7 ft. high in the clear. It is built of pine, with cherry interior finish. There are windows all around, each 1 ft. 8 in. by 2 ft. 9 in., placed 3 ft. above the deck. It is fitted with steam steering wheel of polished brass, mahogany binnacle, eight-day clock, bell pulls, telltales and speaking tubes.

In the forecastle there is a combined steam and hand-steerer, the steering-rod passing down from the pilot-house through the mess room in a brass pipe. There are radiators in all the living quarters piped for steam heat. Other apparatus for the use of the deck department includes a galvanized gypsy windlass for 5-8 in. chain, secured abaft the forward bitts, with chain pipe leading to the locker in the forepeak, hose rack, hand force-pump, and 350 lb. folding galvanized anchor and 60 fathoms of 5-8 in. close linked chain, fog bell, 10 in. dia., 4 ft. foghorn, fire buckets and axes, and 60 regulation pattern life preservers and Lyle gun.

STEEL TUG, RICHARD CROKER.

The propelling engine is of the triple expansion type, with cylinders 13 in., 21 in., and 32 1-4 in. dia., and 24 in. stroke, designed for about 800 I. H. P., at 180 revolutions. It has an open front, with turned steel columns, and the back columns, which carry the slipper guides, are cast iron, resting on the condenser. The H. P. valve is a piston valve, and the other two double-ported slide valves, all worked with the regular Stephenson link motion. Piston rods are forged steel 2 7-8 in. dia., with cast iron pistons fitted with cast iron rings. The connecting rods, of steel also, are 60 in. between centers, with forked upper ends and gib and cotter crank boxes. The built-up crank shaft has journals 7 in. dia. and 6 5-8 in. long, with cranks set at 120 deg., having pins 7 in. dia. and 6 1-8 in. long. Crank, thrust, and propeller shafts are mild open-hearth steel. The thrust-bearing is provided with five horseshoe collars, lined with white metal and mounted on 1 1-4 in. steel screwed rods, with composition distance nuts. For handling the engine, a steam reversing gear of the floating lever type is fitted.

All pumps are independent, and they include a vertical single steam cylinder air pump, centrifugal circulating pump, vertical duplex feed pump, auxiliary feed pump, fire pump, 8 in. and 5 in. by 12 in., arranged to draw from the tank, sea, or bilge, and discharge into the feed pipe, fire main, or overboard. There is also a bilge ejector. Under the forecastle there are two tanks, each of 1,200 gal. capacity, and under the lower after-cabin there are also two of 775 gal. each.

The boiler is of the builders' water-tube type, with 64.37 sq. ft. grate surface, and 2,975 sq. ft. heating surface. This is connected to a stack, the top of which is not over 25 ft. above the water line, so that the tug can readily pass under bridges in harbor work. The boiler is arranged to be worked with forced draught on the closed ash pit system, a blower being provided in the fire room for this purpose.

Cast iron is the material used for the propeller, which is 8 ft. dia. and 12 ft. pitch, with a helicoidal area of 22.5 sq. ft.

The service performed by the vessel includes towing scows, pile drivers, derricks, rafts, etc., in the harbor and carrying the engineering staff on inspection trips. The maximum regular speed is 16 miles per hour, with 200 lb. boiler pressure and engines developing 750 I.H.P.

Designs for the *Richard Croker* were prepared under the supervision of Engineer-in-Chief J. A. Bensel, of the Department of Docks and Ferries of New York City. The contract price for the tug was $59,500.

BALANCING OF VERTICAL MARINE ENGINES DISCUSSED IN AN ELEMENTARY MANNER.*

BY J. MACFARLANE GRAY.

ELEMENTARY INTRODUCTION.

In the order of nature there is this necessary and unavoidable condition in every action, whether of a minute particle or of a large mass, that if its velocity in any one direction be changed there must be at the same instant, in connection with it, another mass or masses changing their rates of motion in the opposite direction at such a rate of change that, taking together their weights and their changes of velocity, the total change in one direction is equal and opposite to the total change in the other direction.

For example, if, in a steamship, a piston weighing 1 ton has changed its velocity downward from 50 ft. per minute to 400 ft. per minute, then in the identically simultaneous interval of time some other mass or masses in the ship must have changed their velocity upward by an amount equal to 1 ton and 350 ft. change of velocity, or 5 tons and 70 ft. change of velocity, or 70 tons and 5 ft. change of velocity; but, whatever the balancing masses may be, the sum of the products of their weights by their accelerations must be equal and opposite to 1 ton and 350 ft. downwards.

This balancing in nature is not a credit transaction. The acceleration of the piston and the balancing acceleration of the other mass or masses are identically simultaneous and co-existent. They accompany one another, and neither of them could exist for even the one-billionth part of a second separately.

If an engine is so designed that each moving part has continuously its image accelerities of other masses in the engine itself, with their centers of action in the same line, the engine is self-balanced, and it requires no compensatory variation of velocity in any other part of the hull to make up nature's balance, and the stress between engine seat and bed-plate is then that due to the resting weight of the engine only, and the holding-down bolts do no holding down, in regard to the effect of the working of the engine.

If the engine is not designed so as to balance in this way within itself, then must the hull move simultaneously oppositely to the otherwise unbalanced motion of the parts of the engine, with accelerity, which is in amount always the same fraction of the engine accelerity that the mass of the engine part is of the balancing part of the hull. In this way is the vibration of the hull constantly equated to the vibration of the engine.

I am here intentionally leaving out of consideration the part played by the water and the oscillations of the hull as a floating body, and as influenced by waves.

This necessary balancing of accelerations is another way of stating the fundamental principle, that action and re-action are continuously equal and opposite. Another way of stating the same principle is to say that the momentum of the universe is unchangeable.

Momentum of a body in any direction at any instant is the rate at which matter is, in that body, being transported in that direction at that instant. Momentum is, therefore, measured by the arithmetical product of the quantity of matter by the velocity. A heavy body at a low velocity may therefore represent the same momentum as a body of less weight at a higher velocity, the rate at which the transportation of matter in the given direction is going on being the same in the two bodies.

Moment, in science, has just the same meaning that it has in common language—namely, importance. The definition given in Thomson and Tait's *Natural Philosophy* is, "The moment of any physical agency is the numerical measure of its importance." The moment of a force about an axis is measured by the amount of work the force would do in moving through an arc of the same length as the radius or arm with which it acts. The arithmetical product of force by arm is the moment, but the idea in the measurement is force by arc of the same length as radius. When the balancing accelerities are not in the same lines the moments of their forces about any plane must be equal and opposite, if the engine is balanced in tilting action as well as in vertical force.

Change of velocity of matter is produced by force. The heaviness of a body is the force of gravitation, and its amount is measured by the accelerity it produces. "The measure of a force is the quantity of motion which it produces in unite of time." At Berwick the accelerity of gravitation is 32.2 ft. per second every second. This is the number which, slightly varying for different latitudes, is represented by the letter g for them all. The force of the same accelerity is the same, whether the change of velocity be the effect of gravitation or the result of mechanical action. Given the accelerity of any body in any direction, if we divide it by any g, the quotient will be the force per unit weight producing the accelerity, in units of the heaviness of unit weight at the place where that value of g holds good, no matter where the experiment has been carried out—on the earth, on the planet Jupiter, on the star Sirius, or on any cricket field in stellar space.

When the velocity of a body is increasing in a given direction, the force applied to the body in that direction exceeds the force applied by the body in that direction by an amount equal to the same fraction of the heaviness of the body that its accelerity is of g. I am here distinguishing between heaviness and weight. Heaviness is force; weight is quantity of matter.

When the steam piston is leaving its highest position, at the instant when its velocity is nil, the accelerity is greatest. The acceleration is then also nil. It is important here to apprehend the exact meaning of the terms employed. The word "instant" is literally, "not standing;" and this hint of its meaning, marked upon it, ought never to be lost sight of in making use of the word. "Instant" is not a portion of time. Instant is in time what "point" is in space—position without magnitude. We cannot, therefore, with strict accuracy say "in an instant" or "during an instant," but only "at" an instant. Motion has direction, velocity and accelerity, at any instant; no portion of time is included in the thought. Travel and acceleration are accomplished in time, measured between specified instants.

The popular meaning of acceleration is increase of velocity. I use the word in this sense only, and I employ the word accelerity to denote rate of acceleration.

*A paper read before the Institute of Marine Engineers, London, England.

The balancing of an engine is principally the balancing of the accelerity of the reciprocating parts of the engine—the piston, piston rod part of the connecting rod, etc. The rotating parts—the crank and the eccentric—are dealt with by themselves. The unbalanced vertical forces, in an upright engine, are the most important disturbers of balance. What is the amount of their accelerity at any position of the crank pin, taking at first a slot connecting rod? Generally this is said to be, regarding the connecting rod as of infinite length; but we cannot think "infinite length," and we can all think a slot connecting rod as in the old donkey engines. With this the vertical travel of the reciprocating parts is the same as the vertical travel of the crank pin.

Circular velocities are very conveniently expressed as being so many times the radius length every second. Do not be frightened if I ask you to allow me to represent this number of radius lengths by the Greek letter omega, . Any other unappropriated mark would serve the same purpose, but this is the symbol most generally used in books, and it is well to familiarize our minds with its meaning.

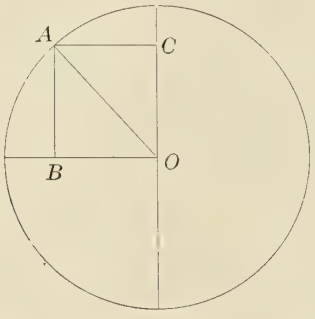


FIG. 1.

When a body rotates with velocity W, it is meant that every point in the body is describing a circle about the axis, or axle, of turning, with a velocity ω radius lengths per second, the radius length being the distance of that point from the axis. It also means something that is far more important. It means that every point in the body is describing circles about every other point in the turning body in the same transverse plane with it, also with the same velocity, ω radius lengths per second, the radius length being the distance between any two points, one regarded as the center and the other as going round it. No matter where in the transverse plane these points may be taken, the same ω, the same number of radius lengths, holds good.

If, then, OA Fig. 1 be the position of the crank, rotating with velocity ω from the vertical, and OC and OB the vertical and the horizontal center lines, the crank-pin A is moving with velocity ω times OA or ω OA in the circle. The velocity of A outwards is at the same instant ω AB, and the velocity of A downwards is $\omega \cdot$ AC. This is just what I have been telling you, that every point moves about every other point with velocity ω radius lengths per second, taking the radius length as the distance between the pair of points, which in this example is AB in one case and AC in the other.

Now, this is only velocity we have arrived at, and it is accelerity, not velocity, which operates in balancing. How can we get accelerity from these two velocities? How can we get the velocity ω. AC changed to accelerity, the rate at which $\omega \cdot$ AC, the downward velocity is changing at that instant? Evidently, if ω. AC be the downward velocity, then W times the rate at which AC is increasing will be the rate at which the downward velocity is increasing. The rate at which AC is increasing is the rate or velocity at which A is traveling outward, which we have seen to be $\omega \cdot$ AB; therefore $\omega \cdot \omega \cdot$ AB, or ω^2 AB, is the downward accelerity of A in this position. After A has passed the horizontal center line, AC will begin to decrease and the downward accelerity will then be negative, or $-\omega^2 \cdot$

In this problem we have an example of a kind of family of lines, BA, OA, CA; and just as in human relationships it is a great convenience to have one word—uncle, aunt, cousin, etc.—instead of telling the whole story of the intermarrying and propagation, so in geometry there are single words which express the relationship of BA and of CA to OA for any position of OA. When a line OA is drawn at an angle to another line OC, the direction of OA is partly sideways from OC, and, partly, the direction coincides with the direction of OC. The fraction that the sideways motion is of the line OA is called the sine of the angle AOC, and the fraction that the motion of A coincides with the direction of OC is called the cosine of the angle AOC. The fraction which CA or OB is of OA is therefore the sine of the angle AOC; it is the sideway travel. The fraction which BA or OC is of OA is the cosine of the angle AOC, for BA or OC coinicides in direction with the direction OC, from which the angle AOC is measured. I am associating the words "sideway" and "sine," and the words "coincide" and "cosine," merely to help the memory. When the line OA has turned so that A is below the horizontal center line the cosine is then negative. When A is on the opposite side of the line from which the angle is measured the sine is then negative.

Understanding the meaning of cosine and sine, and recognizing these terms when shortened to cos and sin, as they always are in trigonometry—the science of angle measuring—we can now change $\omega^2 \cdot$ AB into $\omega^2 \cdot$ OA cos AOC, or if R be written for OA, the length of the crank, we may write this as $\omega^2 \cdot$ R cos AOC, and if a be written for the angle AOC we can write

$$\omega^2 R \cos a = \text{accelerity} \ldots\ldots\ldots\ldots\ldots (1)$$

If OB and OC are "placed together," each in its own direction, a straight line from the beginning to the end will be OA. The word "component" means, literally, "placed together" or "put together," and OB and OC are therefore sometimes called the rectangular components of OA.

If any number of lines are drawn from O consecutively, that is, "following together," as A, B, C, D in Fig. 2, the ending point being P, then, as before, A, B, C, D are called the components of the line OP, not rectangular, because they are not at right angles. The dotted lines in the figure are the rectangular components of the several lines; they are the A cos a, A sin a, B sin a, B cos a, etc., and to show how the angles are measured from the vertical another figure is drawn with the respective arcs dotted, and you are requested to satisfy yourselves that the sum of A cos a + B cos b + C cos c + D cos d is the same as P cos p, and similarly that

$$\Sigma A \sin a = P \sin p \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Observe the meaning of the symbol Σ the Greek letter Sigma, or capital S. It is used to signify that the sum of all quantities similar to the one written after it is meant, and accordingly I might have written

$$\Sigma A \cos a = P \cos p \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In Fig. 4 I have put together the same components in

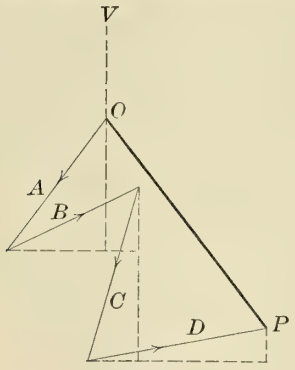


FIG. 2.

a different order to show that the order in which they follow each other is unimportant. The same resultant OP will be obtained. The directions and lengths of the lines alone are important. Observe that the same component is in all the figures parallel and drawn "towards the same parts," as Euclid would say, or "in the same sense," as our men of science now say, the "sense" being indicated by the arrow marks in the figures.

In Fig. 5 the components, A, B, C, D, are represented as crank weights on a shaft O, their resultant being the equivalent crank weight OP. The angles from the vertical are measured as shown, *a, b, c, d, p*.

If W be weight in pounds of the reciprocating parts moving along with crank R, then

$$\omega^2 \text{ W. R. cos } a = \text{weight accelerity} \ldots\ldots (4)$$

at angle *a* from the vertical. Weight accelerity is what

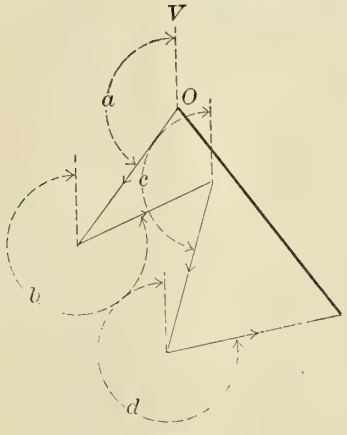


FIG. 3

is called absolute force, or force in absolute units. To bring absolute force to force in pounds at any specified place we must divide by the *g* for the place, say, by 32.2 for force in terms of the heaviness of a pound weight at Berwick. The *g* for London is 32.191, so that the heaviness of 32 cwt. is one pound heaviness less in London than in Berwick, although the weights are the same in the two places. Observe that R must be in feet if, as here, *g* is in feet.

It is more convenient for engineers to employ N = revolutions per minute, and in every case we may substitute

$$\frac{N^2}{91} = \omega^2 \text{ or } \frac{N^2}{2937} = \frac{\omega^2}{g} \text{ when } g = 32{\cdot}2$$

$$\omega^2 \frac{W}{g} \text{ R cos } a = \text{force in pound heaviness} \ldots\ldots (5)$$

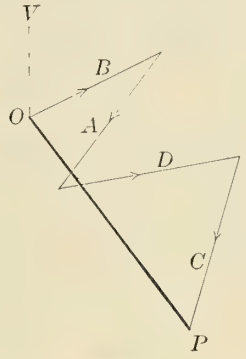


FIG. 4.

In the engine with the slot connecting rod this will be the difference between the steam pressure applied to the piston and the steam pressure transmitted to the crank pin and crank shaft and bedplate. At the same time the upward pressure of the steam, the same as acts downward upon the piston, is transmitted through the cylinder walls to the framing and the columns, and to the bedplate undiminished; and the difference is the lifting force acting on the bedplate and through the bolts, upon the engine seat and the hull in a steamship, relieving the hull to that extent of the weight of the engine. The action is reversed in the lower semicircle of the travel of the crank pin.

It is well to remember that the action is not reversed in the downstroke and in the upstroke, but in the lower semicircle and the upper semicircle.

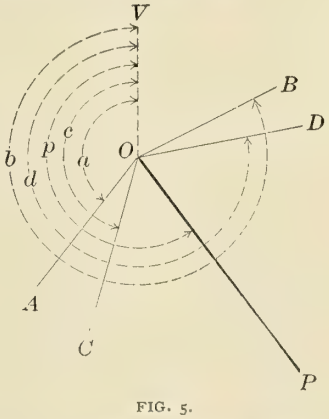


FIG. 5.

In the lower semicircle of travel, in falling, the downward pressure applied by the reciprocating parts is greater than the steam pressure propelling them, for there is then an arrestment of motion, and the excess is the unbalanced force which then depresses the hull. When the bottom center is turned the upward pressure of the steam is similarly, not wholly, transmitted

through the piston rod to the crank pin and the shaft, but the equal downward pressure of the steam is wholly transmitted downwards through the framing and bedplate to the hull, continuing the excess of downward force acting on the bedplate and engine seat and hull. In this way is nature ever watchful to prevent the universe from altering in any direction the motion of its center of mass.

Observe that the expression

Weight accelerity $= \omega^2$ WR cos a.....(6)

is merely an extension of the common formula for centrifugal force, which in absolute units is

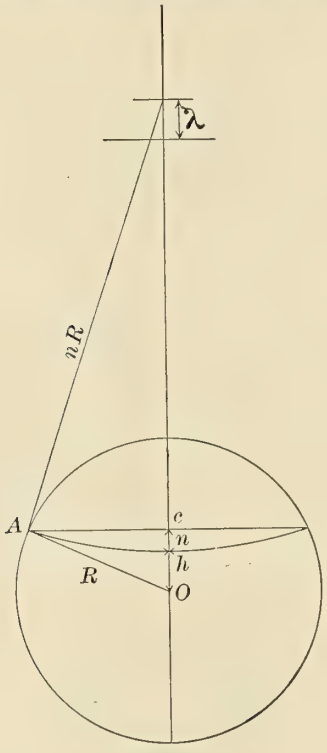


FIG. 6.

$$F = \frac{V^2}{R} W$$

when F = force in absolute units and V is velocity in feet per second. It must be observed that $V = \omega R$, therefore

$$\frac{V^2}{R} = \frac{\omega^2 R^2}{R} = \omega^2 R,$$

and $F = \omega^2 WR$.....(8)

and in (6) the only alteration is that R cos a is substituted for R, extending the centrifugal force formula to give the component forces in any direction for any position of the weight W in moving round a center O at distance R. The component forces are

ω^2WR cos AOC in the OC direction..... (9)

and ω^2WR sin AOC in the OB direction.....(10)

We might have started from the rule of centrifugal force, and at once have resolved it into these components, but I have led you the longer way about to make the nature of the problem clearer.

When a swinging connecting rod is employed, the vertical movement of the crank pin is not the same as the movement of the crosshead and piston. Concentrating the whole of the reciprocating weight in a piston, the problem of the effect of the rod's obliquity may be represented diagrammatically as in Fig. 6, where h = the distance of the piston from the half stroke position, nR is the length of the connecting rod, and the half chord Ac = R sin a, and x is the amount that the piston is in advance of the crank pin. I wish to take you all along with me in my reasoning, and I therefore recall to your minds some very elementary matters, which the majority of you know as well as myself, but one or two may not remember the reasons why. In a right angled triangle the square upon the side opposite the right angle is equal to the sum of the squares upon the

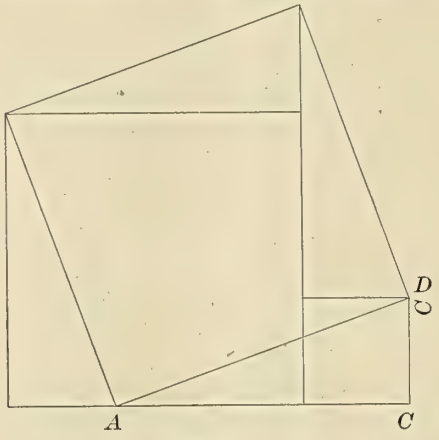


FIG. 7.

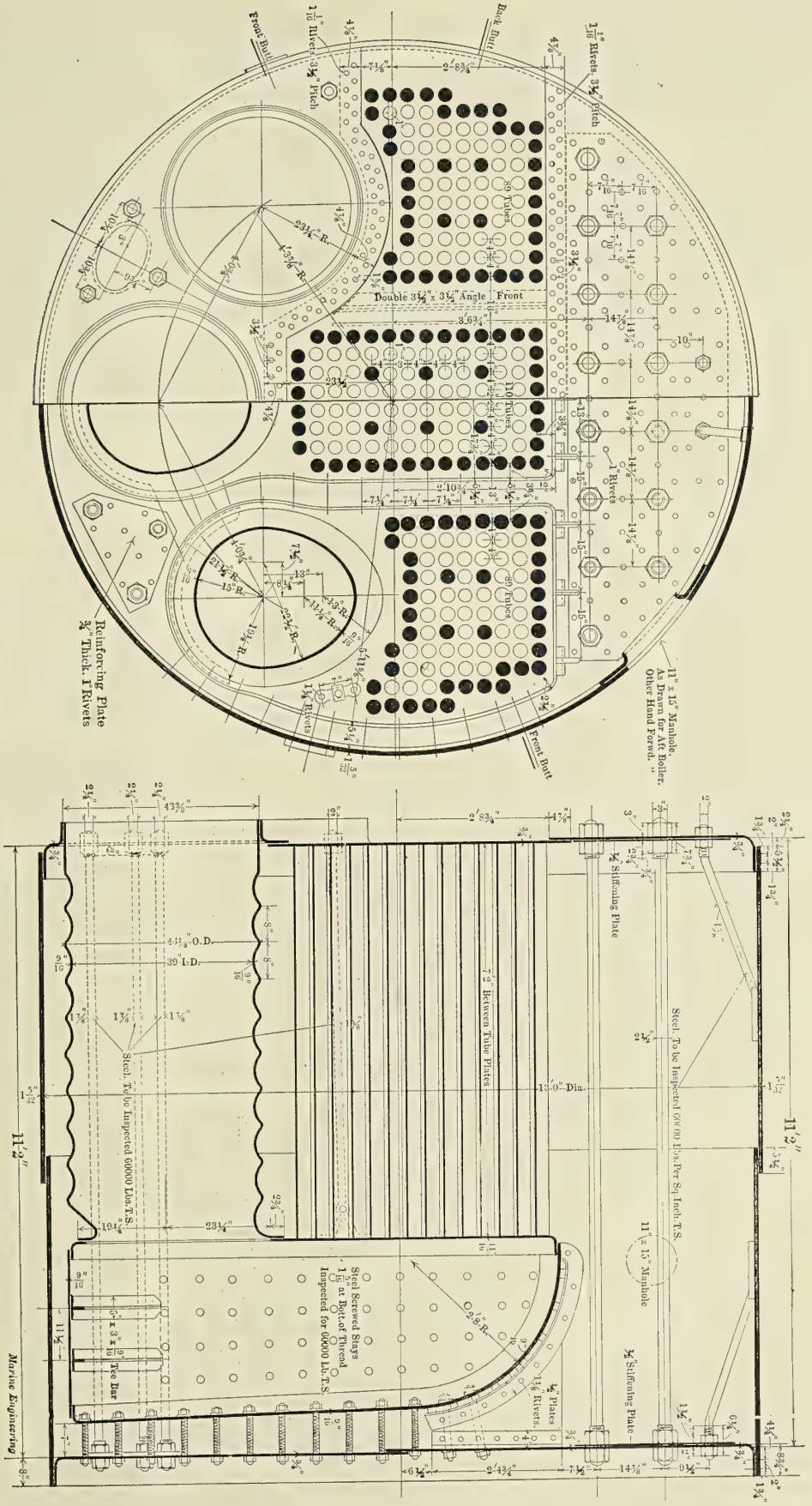
other two sides. That is to say, in Fig. 7 $AC^2 + DC^2 = AD^2$, which is obvious from the figure, but the demonstration is made still clearer when the diagram is formed in cardboard, and actually cut as the Chinese make it in ivory.

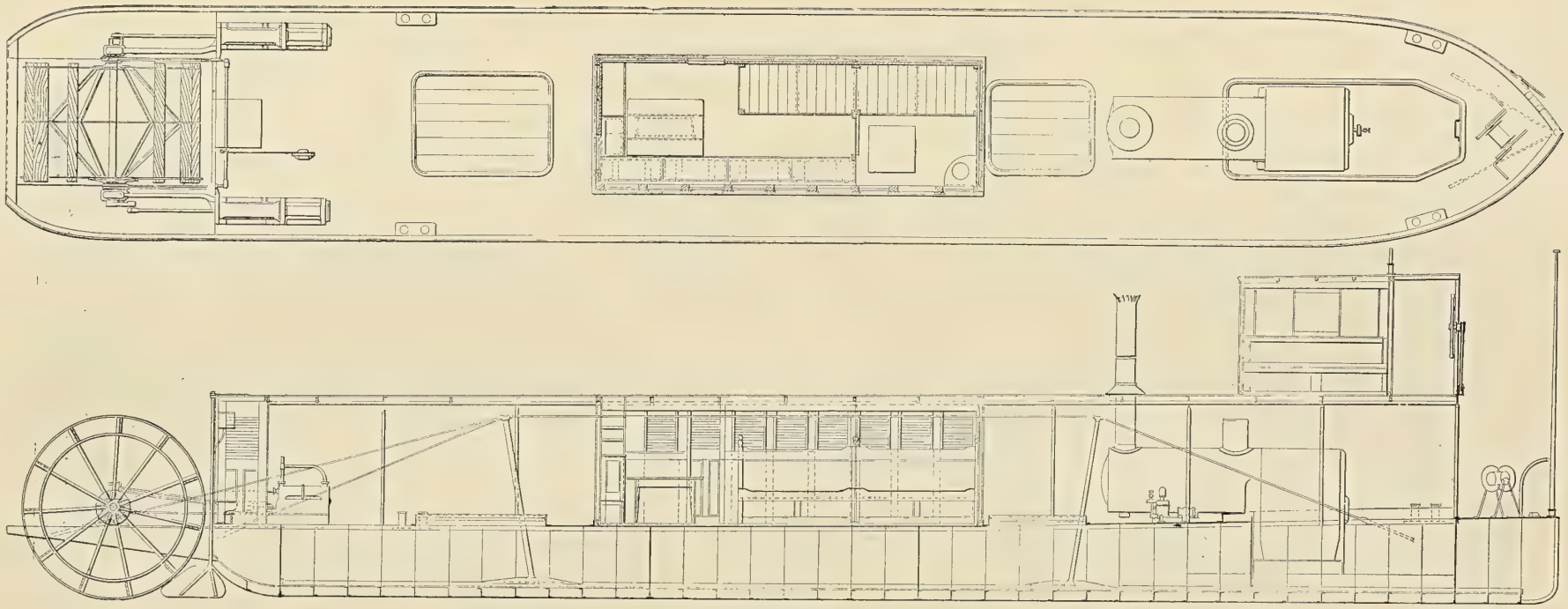
(To be Continued.)

High Pressure Scotch Boiler.

In the accompanying scale drawings are shown the construction of a Scotch boiler, which formed part of the machinery equipment of a moderate sized, sea-going, steam vessel, equipped with triple expansion engines. The boiler, as can be seen at a glance, is of the single ended, three furnace type, with separate combustion chambers, and is of these dimensions: Length, 11 ft. 2 in.; diameter, 13 ft. It is built of open hearth steel of a tensile strength of 60,000 lb. per sq. in. It was designed for construction in a plant fitted with heavy hydraulic tools, and it will be noticed that the back head is flanged outwardly for machine riveting. The tops of the combustion chambers are curved and stiffened with T bars, thus getting rid of one joint in each chamber, and the complication of crown bars and screw bolts and nuts. There are only two horizontal rows of main braces, the upper stays being diagonal with flanged inner ends riveted to the top of the shell. Morison furnaces with Gourly flanged ends are used, so that the furnaces can readily be withdrawn without, practically, dismembering the boiler. It was built to carry a working pressure of 175 lb. per sq. in. On the front elevation the stay tubes are indicated by solid ends. The boiler is well proportioned, a free steamer, and is a good example of modern American practice.

MODERN HIGH PRESSURE SCOTCH BOILER.





DECK PLAN AND INBOARD PROFILE OF MISSIONARY BOAT SAMUEL N. LAPSLEY.

Stern Wheel Missionary Steamer "Samuel N. Lapsley."

An interesting example of light draft special purpose boat is found in the stern wheel missionary steamer *Samuel N. Lapsley*, which was recently completed by the William R. Trigg Company of Richmond, Va., for use on the Congo River. Owing to the shallow water the boat will necessarily encounter, particular care had to be taken in its design to enable all requirements to be met. It was requisite that the boat have as light a draft as possible, yet a large cargo space was at the same time necessary. This was accomplished by giving a flat bottom and slightly rounded bilge, with a short, yet gracefully curved bow. The chief dimensions are as follows:

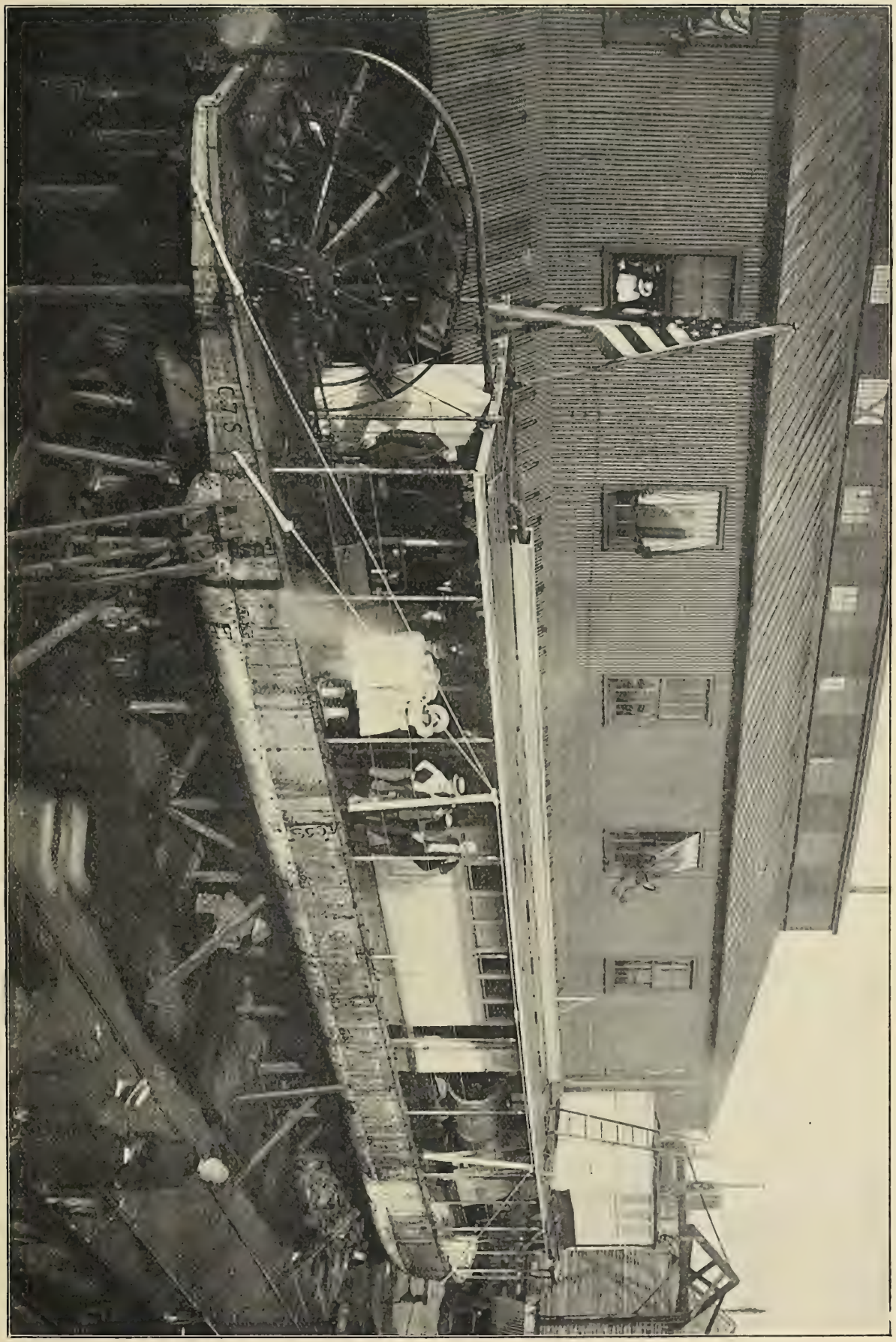
Length over all	70 ft.
Beam	12 ft.
Depth	3 ft. 6 in.
Draft	1 ft. 1 1-2 in.
Normal displacement	30 tons
Speed	8 3-4 knots

As the boat is intended to carry both cargo and missionaries to and from various points on the Congo, it is readily seen that comfort and space entered largely into the requirements.

The hull is built of steel throughout, with four transverse watertight bulkheads, and has ample space to store cargo. The forward compartment is occupied by the boiler and fuel space, while two large cargo hatches,—one forward and the other aft of the deck house,—give entrance to the remaining compartments.

The hull is trussed by means of tie rods, provided with turn buckles and supported by king posts. The deck plating consists of 5-lb. plates, with 7-lb. plate stringers connected to the sheer strake by 3-in. by 6-lb. gunwale angles. The keel, side, and bilge plating are of 8-lb. plates, while the bottom plating is made of 6-lb. plates. These have lapped seams with butts strapped and double riveted.

The deck house, which contains two rooms, is situated amidships and is built and framed of pine finished in white. The forward room has two bunks, lockers, wash basin, etc. The after room, besides the above, contains also a transom, pantry and folding table. Both rooms are well ventilated by numerous windows. The toilet room is situated aft immediately forward of the paddle wheel. On the upper deck, which runs the length of the boat, is the pilot house containing one bunk, and finished the same as the deck house.



LIGHT DRAFT MISSIONARY BOAT SAMUEL N. LAWSEY

The boiler is of the locomotive type, with a grate surface of 350 square feet. The steam pressure is 150 pounds per square inch.

Placed aft are two horizontal, simple non-condensing engines with cylinders 9 inches diameter and 24 inches stroke. These are connected to the stern wheel which makes about 45 revolutions per minute at full speed. The engines develop 70 I.H.P.

An interesting feature of this boat is that it was taken completely to pieces, boxed up and sent to New York in freight cars, where it will be transferred and shipped to Africa.

The expense of the building of the boat was defrayed by various societies of the Southern Presbyterian Church. The christening took place in the yards of the William R. Trigg Company on June 23 before a large assembly, composed chiefly of members of the societies that have done so much to have their faith sent to the dark continent.

A PRACTICAL GEOMETRICAL METHOD OF LAYING OUT SHIP VENTILATOR COWLS.

BY C. M. JONES.

If two thin rings be secured together in any way and at any angle consistent with rolling, the trace due to rolling on a flat surface will be a pattern that cut from relatively thin sheet metal will form into a segment having bounding edges corresponding to the curvatures of the rings.

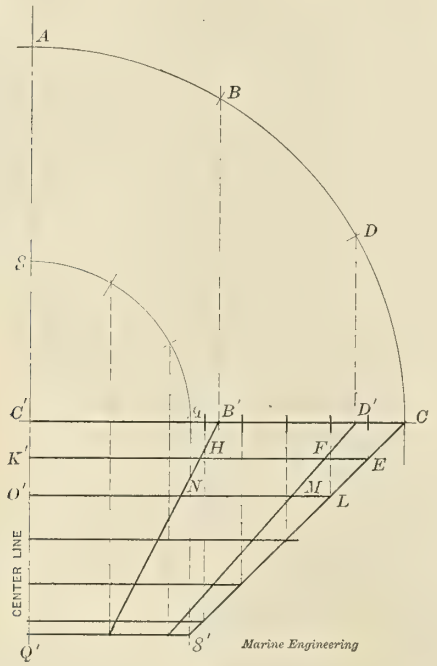


FIG. 3.

If points be marked off on either of the rings, and when in contact with the flat surface, the points of contact of the opposite ring be noted and marked, then straight lines drawn between such corresponding points on the pattern will remain straight when the segment is formed up.

The fact that such straight lines or elements of the surface can be found from the drawing of the segment enables the trace or pattern to be drawn without resource to actual rings, whether the segment be circular, elliptical, egg shaped, or of any other rational form of cross section.

Ventilation cowls aboard ship are generally of circular section, although sometimes made egg shaped at the mouth and gradually merged into a circle at the neck. Rarely they are made lop-sided, when fixed permanently in direction close alongside some obstruction.

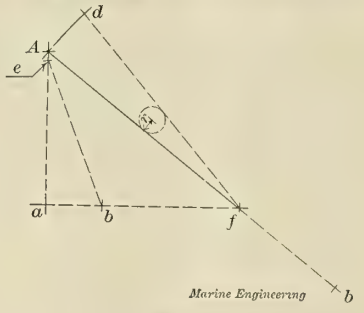


FIG. 4.

The method of development here given is for circular sections, but its general features are universally applicable and will enable all types to be laid out with the fewest possible lines and the greatest accuracy; the segments, when formed, simply "mopping" together if any sort of care has been used in the construction.

In Fig. 1 draw the profile *A, Z, I, 8, L* from the given sizes of neck and mouth, the throat radius being made as small as consistent with the necessary laps, and the "crown" curve being often struck, with a radius from some point on the horizontal through *8, Q*.

A circular crown curve, however, makes the inlet too flat at *E*, and the curve shown—which is between a circle and an ellipse—gives a better entrance for the air. The height, 8.0, is divided into eight equal parts, and the offsets—given as fractions of the total distance, *A, o,*—are set off and a smooth curve drawn through the points.

Divide the crown and throat into any desired number of equal parts—six are shown, but seven are usual—in order that the palm for the center pivot at *L*, on which the cowl turns, may be conveniently fitted, and drawn preliminary joints such as *EI. LO*, &c., and project the centers of such joints upon a center line, Fig. 2.

Set off the preliminary radii as *CA, KE, OL*, &c., from the center of Fig. 2, and through the points *C, K, O, Q* draw a curve as shown, and if it is not smooth and "fair" make it so and readjust the radii and crown curve to suit.

A thin flexible batten held to the points by means of weights or "dolphins" gives the best results for all such work.

Secure the batten "up and down" with the center line of Fig. 2 at the point *Q*, and then bend it to each of the other points. Place two dolphins at *Q*, one at and one *below* the point, and one at each of the other points. Hold *Q* and *C* and raise and then lower each dolphin *separately*, noting in which direction the batten tends to spring, if at all, when freed. A little manipulation of the points will secure radii on the curve of which the batten will lie neutral, and the crown curve must then be changed to suit, adjustment being continued until both curves are found "fair." The corrected crown

curve is then divided evenly and the true joints drawn in permanently.

In Fig. 3 describe quadrants[1] *ABDC,—8q.*, with radii of mouth and neck of ventilator, respectively, and divide each into, say, three equal parts. Draw *C,'C*, and *Q',8'*, equal to said radii and at such a distance apart that *c',8'*, the line joining them, will stand at about 45 degrees.

Project down the divisions of the quadrant, each upon its line, as shown, and draw straight lines *CL8'*, *D'FM*, *B'HN*, through the division points, and setting off the correct radii of the cowl joints and getting intersections on the slant line *C,8'*, such as *E,L*, &c., draw horizontals *EK'*, *LO'*, &c. The intersections of these horizontals, with the slant lines drawn between semicircle, *EfhKI*, the base circle, and project (square to *EI*) the points *F,H,K,R*, &c., to *f,h,k*, &c., or better, to avoid errors of projection, divide the base circle into the proper number of parts. Project *A C* and *Z* down upon the base line *I,E* (Produced to *a* and square of course to *EI*), thus getting the points *a,X,I*—the latter nearly. As *Xa* is very nearly equal (here) to *CA*, set off *Xc* equal to *CA*, and taking *Xa* as radius, sweep a semicircle through *c* from the point on *XC* shown a little to the right of *X*. This semicircle (properly a nearly circular semi-ellipse), is the plan curve of the ventilator mouth.

Project (square to *EI*) *B,D,C*, &c., the points of division of the face, upon this mouth curve, getting points *b,d,c*, &c., and pin such points with the corresponding

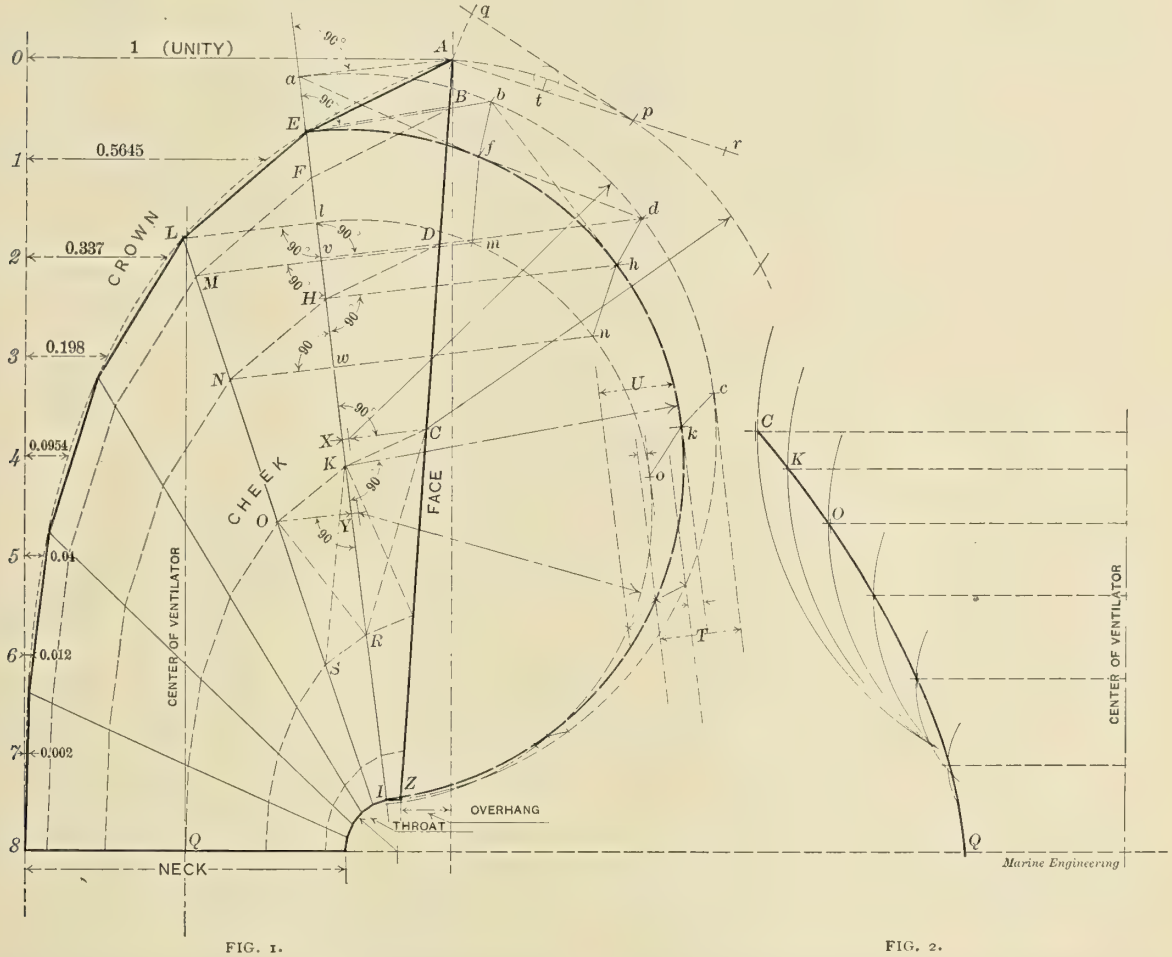


FIG. 1.

FIG. 2.

the division points, give division points for all the cowl joints. Setting off both sides from *C,K,O*, &c., (the centers of joints) of Fig. 1, the distances *C'B'*, *C'D'*, *K'H*, *K'F*, &c., of Fig. 3, and drawing the straight lines shown, such latter lines are in profile the elements of the surfaces from which the developed segments are determined.

In Fig. 1 consider *E,I* the base joint for the segments right and left of it, and from the center *K* describe a points of division *f,h,k*, &c., of the base circle by means of straight lines, as per figure. These lines, *bf*, *dh*, *ck*, &c., are the surface "elements" in plan.

In Fig. 1 from *C* as center, strike an arc *Ap* (radius *CA*) and set off *AP* equal to *AB* of Fig. 3. This forms one division of mouth circle. Prolong the chord to *r*—making *pr* equal 1-2 *Ap*, and from *r* as center, strike an arc *Aq*. At *t*, the half chord, draw a circle with radius equal to the "round up" (or versed sine) of the arc as shown, and draw *pq* touching it. This last line will be tangent at *p*, and *pq* will be the true length of the arc,[2]

[1] This is for a circular cross section. For other shapes the points must be found by determining positions on the curves of tangents that are parallel in one plane.

[2] "Rankine's Rectification of Circular Arcs."

as closely as can be measured. This length is to be used in getting the distances *AB, BD, DC,* &c., shown in Fig. 5. *AE* in Fig. 5 being equal to *AE* in Fig. 1.

Find also the true length of the base circle arc *Ef*, this being used to set off *EF, FH, HK,* &c., of Fig. 5, as well as the upper division of the second section shown in same figure.

In Fig. 5 strike from *A* the true arc *pq* of Fig. 1, as above and also strike from *E* the true arc *Ef* of the base circle. In Fig. 1 take the diagonal chord *af*, and drawing a right triangle as in Fig. 4, set off said diagonal on the base as shown. From Fig. 1 take *Aa* in the dividers (the square distance that *A* is above the base

In Fig. 4 take *ab* equal to *fb* of Fig. 1, and also *ae* equal to *BE* of latter figure — *BE*, meaning here the distance from *B* square down to base line, *IE*, the perpendicular lying (by chance) close to crown point *E* — then *eb* Fig. 4 is the true length of the straight inclined element — *fb* of the plan Fig. 1, or profile *BF* (Fig. 1), and in Fig. 5, *FB* must equal this true length.

It will often occur that the first found points *B* and *F* of Fig. 5 require slight adjustment to conform to this latter standard check, as small errors are practically unavoidable, even when extreme care and good instruments are used. Ordinarily, however, correction can be made by the eye, and in any case dividing the joint curves

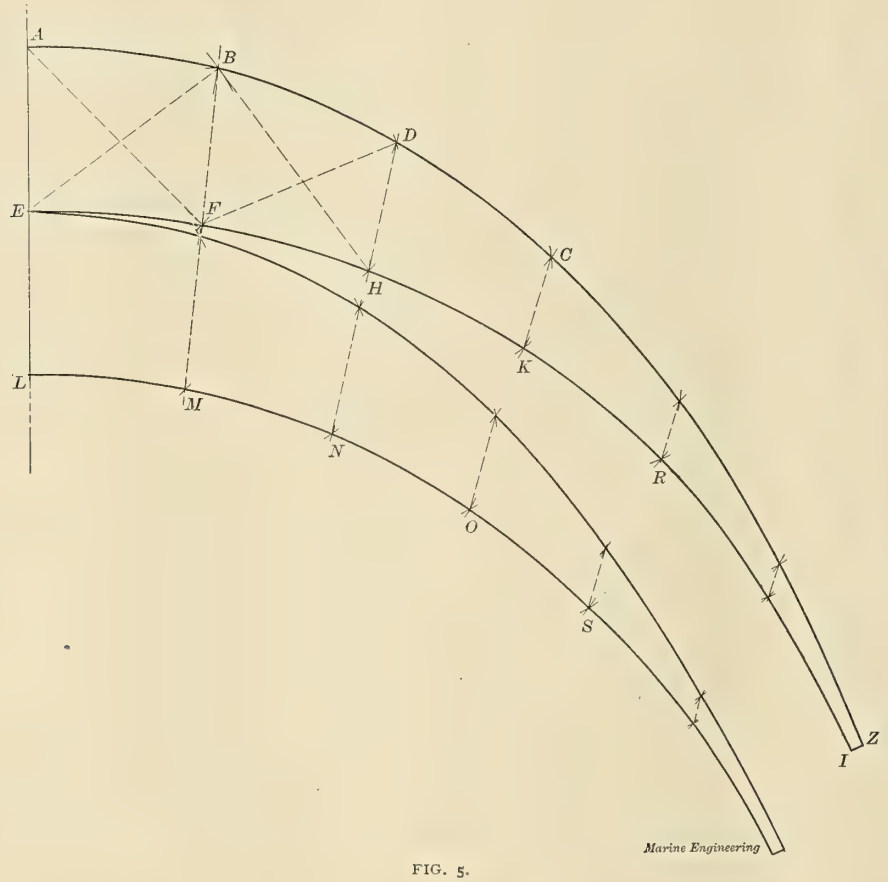


FIG. 5.

IE) and set it up as *aA* in Fig. 4. Draw *Af*, then this latter line is the true length of a straight chord (*af*) of Fig. 1.

Bisect this latter line and set up *r* — equal to the mean (half sum) of the round ups of the arcs, *Ap* and *Ef* of Fig. 1, and draw circle as shown, with *r* as radius. Draw *fd* touching this circle and prolong *Af* to *b* (*fb* = 1-2 *Af*). Strike from *B* on through *A*, cutting *fd* in *d*. Then *fd*, Fig. 4, will be very nearly equal to the true diagonal *AF* of Fig. 5, and from *A* (Fig. 5) as center and such diagonal as radius an arc struck through the already drawn joint arc at *F* gives *F* as point on the developed segment.

In the same way find the true lengths of diagonal *Eb* of Fig. 1, and with it as radius and with *E* as center find point *B* of Fig. 5, and draw straight line *BF* in the latter figure.

of Fig. 1 into smaller portions will show where the trouble lies.

Such subdivision should in most cases be carried out at the throat portions of the segments, as the intersecting arcs (Fig. 5) there make too acute angles to give satisfactory points of reference.

The points *BF*, Fig. 5, being determined, strike from them the joint arc lengths *BD* and *FH* and find their true lengths of curved diagonals — *bh* and *fd* of Fig. 1, being the plan lengths for one leg of the triangle and the heights *BE* and *Dv* being the other legs, from which to find the lenghts of *straight* diagonal chords and in this way continue until the whole half segment is laid out, the opposite half being its duplicate.

The second segment is found by projecting the center point, *O*, square to the base circle line *IE*, getting *Y* as projected center, and setting off the eccentricity as

shown at *Y*, describing the circle *l, m, n, o, I* (the distance *oY*, square to *IE*, being equal to *OL*, the true radius of joint *L O S*), and getting the surface elements, diagonals, arcs, as for the smooth curve.

The point below or at left of *L M N O S* is to be used as base for the middle two segments, and there are, therefore, three distinct bases for the cowl shown.

The setting off of the eccentricity at *X* and *Y* instead of drawing the true elipses due to angularity of *AZ* and *LS* in relation to the base circle affects the result only to extent of actually making the segments form up into the curves drawn, instead of into perfect circles. Where eccentricity is great, due to rank angles at *AEL*, the true ellipses should be drawn if perfectly circular sections are desired.

A second method of getting the lengths of the straight diagonal chords (such as *Af* of Fig. 4) is as follows:

Let *CR* of Fig. 1 be required. Take *CR* as one leg of the triangle—previously explained—and through *c* on the mouth curve and the point corresponding to *R* (this latter is shown, but not *marked* on the base circle), draw parallel lines—parallel to the base line *EI*. The distance *T* between such parallels is the second leg of the triangle, and the diagonal thus found will be equal to that found by the first method given, but the legs of the triangles will usually differ.

These methods check each other and serve to point out errors of construction due to confusion of lines.

After the points of the developed segments are laid down as in Fig. 5, a flexible batten should be pinned to them and smooth curves drawn as shown. These lines are "construction lines," and the laps must then be set off and second lines drawn by which the segment is to be cut.

The joint laps are usually allowed on the convex side of the developed sections, or rather the lower segments have lap on their upper edges which enter the segments above them.

The mouth is finished by bending over a heavy wire or by a tube split and bent to form, the segment edge being brazed (or otherwise fastened) into the slit. In either case lap, or its equivalent, must be allowed.

The neck is usually riveted into a toothed ring that engages with a pinion to allow swinging the cowl from below decks to face the wind.

If the joint circles of a cowl be divided into parts such that the chords are near enough equal to the arcs, the refinement of allowing for round up can well be dispensed with.

Cowls of copper, such as fitted aboard naval vessels, are frequently formed of four pieces, crown, cheeks and neck, brazed together into rectangular cross-sections, and then beaten into smooth finished shape.

A very much less expensive method is to form them of three or more sections by the method here laid down and then, after brazing, bring them to finished size with the hammer, with a minimum of labor and the certainty of having practically uniform thickness of metal.

Twenty-eight vessels large and small are now under construction at the Crescent Shipyard, Elizabethport, New Jersey.

TORPEDO CRAFT—UNITED STATES AND FOREIGN-TYPES AND EMPLOYMENT.*—I.

BY LIEUT. R. H. JACKSON, U. S. N.

The navy list, on July 3, 1899, showed that we had, completed, 20 torpedo craft, and building, 33 more; in all, practically 50 of these vessels.

It is now time to ask ourselves what success we have attained with these vessels and what should be accepted as the standard type for performing the functions required for such vessels.

Three years ago, a paper on this subject, written by Lieutenant R. C. Smith, U. S. Navy, was published in the institute; he outlined the practices of the builders abroad at that time, and deduced from them, from the conditions to be fulfilled in our service, and finally from what experience had taught us with the two or three boats already built, that two types of boats were essential, advocating the building of only these standard types; he also pointed out some of the objections that would result from great variety in type and size.

Let us then examine our list of torpedo craft and see if they can be classified into two types. It will be seen at once that any attempt to arrange them according to length, displacement, speed, or armament, is practically impossible. It is only in the destroyer class, where a batch of sixteen were laid down at one time, that there seems to be anything like a standard. In this class we can say that there are sixteen boats with displacement of from 400-420 tons, with H. P. from 7,000-8,300, and a speed of 30 knots over a thirty-mile course. Having set this type to one side as a destroyer class, there remains on the list of torpedo boats from 46-175 tons, intermingled with destroyers from 146 tons to the standard destroyer of 420 tons; speed from 20-30 knots; and an armament of torpedoes and battery with but little more regard to law and order.

It is natural that these conditions have arisen, and far from regretting that such is the case, it may prove to have been of considerable benefit if properly considered.

Some of the reasons for our heterogeneous collection of torpedo boats may be found dependent upon the following conditions:

(*a*) It was the desire and policy of Congress to scatter the work throughout the country in order to foster the ship-building policy, and to develop the specialty of building small craft. This allowed many small firms that had but little experience in building vessels of this type to bid and submit plans, as it required but a small plant to turn out these vessels.

(*b*) Besides the variations resulting from the acceptance of plans of the different contractors, other variations constantly arose from practical difficulties met with by the contractors in carrying out the specifications. Some of these, no doubt, were due to lack of skill on the part of the contractors, and others to faults in the department's designs; others possibly to a desire on the part of the contractor to use a cheaper and possibly equally good design to replace the more costly one laid down by the department.

*Prize essay read before the U. S. Naval Institute, Annapolis, Md., and copyright, 1900, by R. H. Jackson, U. S. Naval Institute.

(*c*) Possibly a desire to build experimental types can account for some of the variations.

At any rate we have them; and having them, a close study of the performance of the different types, and their efficiency in the special rôle to which they should be assigned, ought to give us much valuable information, and lead to the selection of two, or at most three, types of boats that can then be standardized as far as possible.

In order to decide upon these types, information may be obtained from three sources.

First—The practice abroad of the leading powers. Until recently this has been almost the only source from which conclusions could be drawn; so, too, there ought to be a perfect familiarity with the results that are attained abroad with the different types in order to more closely judge the efficiency of our own types.

Secondly—The examination of the performance of our boats during the Spanish war, in which they performed almost every function except the one which properly belonged to them—that of attacking an enemy's fleet. Many important lessons in construction and engineering can be drawn from this source; but nothing tactical.

Thirdly—Consider the strategical points involved as a result of our isolated position, and the requirements for torpedo boats that are demanded thereby. From this, certain qualities will be found as absolutely essential for one class of boats, and certain others as the essential features of another. Knowing, then, what is to be required of the boat, an examination of the performance of our own boats and of those abroad should enable us to select the type of boat as a standard, possessing such qualities to the highest degree, and all boats should then be required to conform to this standard even to the most minute details.

The advantage of possessing uniform qualities is even greater in its application to a flotilla of torpedo boats than when applied to battleships. Equal speed, steaming radius, interchangeability of parts, all add materially to efficiency and economy of the boats.

Classification—Before entering into an examination of foreign practice, it would be well to fix our ideas by the selection of certain standards of comparison. The following classification is based on the displacement as giving the best indication of the sea-going qualities of the boat.

(*a*) Class O. Destroyers. Boats of high speed over 200 tons displacement; carrying guns and torpedoes.

(*b*) Class P. Sea-going torpedo boats (picked). All boats over 150 tons; they are capable of maintaining themselves at sea as long as there is a demand for their services; though on account of the relatively small number of officers and men, and the cramped quarters, they should be allowed to leave the squadron and return to port when opportunity offered.

(*c*) Class Q. Sea-going torpedo boats (questionable). All boats between 100 and 150 tons; these boats are sea-going, but not sea-keeping; two or three days continuously at sea being about all they can stand.

(*d*) Class R. Torpedo boats (stationary). All boats under 100 tons. They are properly not sea-going, as there is certain risk incurred in sending one to sea alone, especially for a sufficient distance to prevent her again reaching port before foul weather sets in.

The same letters are used in this classification. by displacement, as are used in the English *Naval Pocket Manual* (where the classification is by length), by far the most complete and accurate list of torpedo craft now published.

The principal changes from the tables given in the manual are: (1) It reduces very much Class P (sea-going), also known as sea-going torpedo boats, throwing most of them into Class Q (questionable), also known as first-class boats; (2) it very much increases Class R (station boats). This class embraces all, or practically all, of the boats known as second-class, and some of the so-called first class boats.

The following table shows the classification more clearly:

CLASS.	DISPLACEMENT.	NAME.	LOOSE CLASSIFICATION.
O..	200 and over.	Destroyer.	Destroyer.
P..	150-200	Sea-going, picked.	Sea-going.
Q..	100-150	Sea-going, questionable.	1st class and sea-going.
R..	Under 100	Station.	2d class, station, vedette.

(To be continued.)

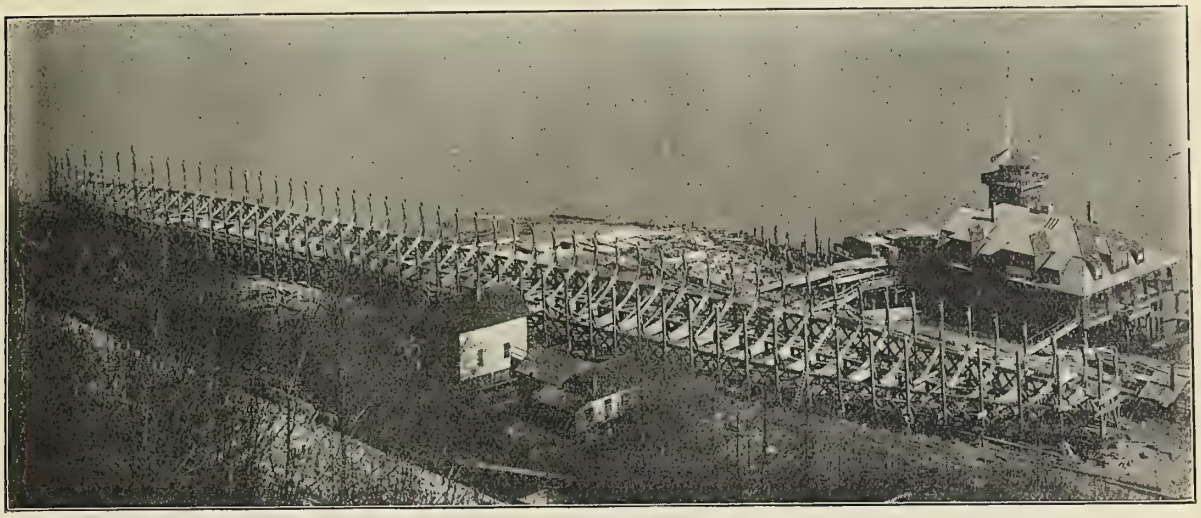
Ocean Lumber Rafts.

The announcement that an immense pile raft is now under construction on Puget Sound to be towed to Japan serves to call attention to one of the most interesting industries on the Pacific coast, and one in which the shipping interests are directly interested. The rafts constructed by Capt. H. R. Robertson on the Columbia river and Puget Sound during the past year or two are not only the largest of the kind ever built, but are in many respects of unique construction. Capt. Robertson some fifteen years ago commenced the building of these rafts on the Atlantic coast, but learning of the immense quantity of piles on the Pacific coast decided to transfer his operations, and has lately established a permanent raft building plant at West Seattle, Wash. It is anticipated that henceforth three or four rafts of the largest size will be turned out each year.

The average raft constructed by the Robertson Raft Co. is 625 feet in length, 55 feet beam, 38 feet depth and 24 feet draught of water. The hull and cargo of each comprises some 11,000 piles and upwards. These raft structures have all the appearance of a whaleback, being pointed at each end, with a hull outlined and built to buffet the heaviest seas with the safety of a sailing vessel. Indeed the builders claim that if fitted with rudder and canvas they could make very fair progress on their own account. The 11,000 piles which are worked into a raft of this kind average 60 feet each in length and the huge structure thus contains in the neighborhood of 660,000 lineal feet or about eleven times the pile cargo of a fair-sized sailing vessel.

The fact that one of these immense rafts may be taken to its destination with average safety and without the expense of employes beyond those on the towing steamer is an additional point in their favor from an economic standpoint. Indeed the only expense in building and marketing the raft is found in the first cost of the cradle; the services of about a dozen employes being required for three months, the

time ordinarily required for construction; and the outlay for some 5,000 feet of chain which is utilized to hold the piles together in their original form. The cost of the entire structure, including the cradle, does not exceed $5,000. The majority of the rafts which have heretofore been constructed by the Robertson Company have been towed to San Francisco and sold. The prices which they have brought would seem to insure an immense profit for the builders, but possibly the figures are not unduly high considering the risk involved.



CRADLE FOR LUMBER RAFT.

Probably the most remarkable feat in raft building which has ever been accomplished was performed recently at the West Seattle yard when a raft which was originally intended to consist of 12,000 piles was enlarged, and when completed contained fully 2,000 piles in excess of the original estimate.

Shipping interests on the Pacific have carried on some agitation against these immense rafts on the ground that the piles if broken up and scattered in a storm would prove a serious menace to navigation, but no active steps have been taken to restrict their construction. The raft builders, on the other hand, declare that they have taken precautions to reduce the danger to a minimum. The chains wrapping the hulk are two inches in diameter, and in addition to being placed only six feet apart from end to end are interwoven and bound in the staunchest possible manner, so that nothing but the severest storm could possibly disrupt the mass.

OCEAN LUMBER RAFT.

U. S. Torpedo Boat Destroyer "Dale."

In MARINE ENGINEERING for August brief mention was made of the launch of the torpedo boat destroyer *Dale* on July 24 at the yards of the Wm. R. Trigg Co., Richmond, Va. The following particulars, together with the accompanying view of the launch, will be of further interest.

The *Dale* is the first of the sixteen destroyers now building for the Government to be launched. As it was a side launch, unusual interest was created and upwards of 5,000 people witnessed the scene.

Miss Mary H. Wilson, of Philadelphia, a descendant of Commodore Dale, after whom the boat is named, acted as sponsor and succeeded very well in breaking the bottle of "yellow label" over the bow of the destroyer as it took its initial plunge. The boat glided smoothly off the ways without a hitch of any kind and came to a standstill after having gone not more than 30 ft., resting gracefully on the water, with every line showing the fineness that will permit the high speed it is designed to make. The dimensions and particulars of the launching ways were as follows:

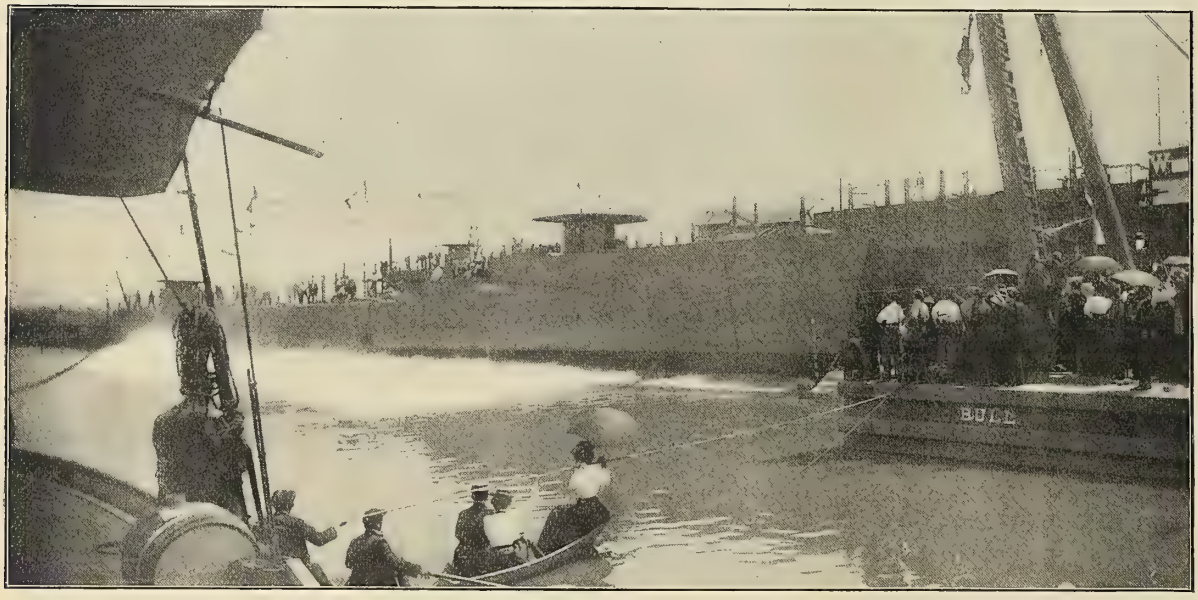
Groundways, 12 in. by 12 in., yellow pine.
Groundway shoes, 12 in. by 1 1-2 in., oak.
Slidingways, 5 1-2 in. by 12 in.
Length of slidingways, 23 ft.
Inclination of ways, 2 in. to 7 ft.
Number of ways, 10.
Bearing surface, 230 sq. ft.
Number of triggers, 5.
Launching weights, 193 tons.
Pressure per sq. ft., .839 ton.

A preparation of No. 1 Albany grease and beef tallow was applied about one-half in. thick on the ways and then covered with soft soap. Owing to the heat, considerable more tallow was used than is usually required.

The dimensions of the *Dale* are as follows:

Length over all	245 ft.
Beam	23 ft.
Depth	14 ft. 3 in.
Draft	6 ft. 6 in.
Normal displacement	420 tons
I. H. P.	8,000
Speed	28 knots
Thornycroft boilers, Daring type	4
Total grate surface	315 sq. ft.
Total heating surface	17,768 sq. ft.
Steam pressure, boiler	300 lbs. per sq. in.

Two four-cylinder triple-expansion engines. Diam. of cylinders, 20 1-2 in., 32 in., and two 38 in., each with a common stroke of 22 in.



LAUNCH OF THE U. S. TORPEDO BOAT DESTROYER DALE.

TORPEDO BOAT BARNEY.—At the yard of the Bath Iron Works, Bath, Me., on July 30, was launched the U. S. torpedo boat *Barney*. This boat is one of the number authorized by Congress in 1898. Her dimensions and chief particulars are as follows: Length, 157 ft.; beam, 17 ft.; depth amidships, 10 ft. 9 in.; mean draft, 4 ft. 8 in.; displacement, 160 tons; speed, 28 knots; cost, $170,000. The armament will consist of three pairs of r. f. guns and three tubes for short 18 in. Whitehead torpedoes.

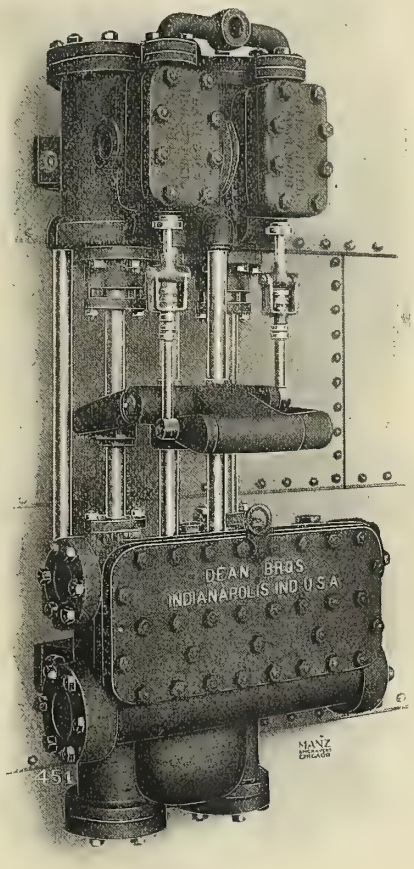
TUG FRED. E. RICHARDS.—At the yard of the Neafie & Levy Shipbuilding Co., Philadelphia, Pa., on July 24 was launched the steel tug *Fred. E. Richards*. The chief dimensions are as follows: Length, 135 ft.; beam, 26 ft. 6 in.; depth of hold, 15 ft. 6 in. The *Richards* is intended for the towing of steel barges of the Rockport Lime Co., of Maine, from Rockland to points of delivery, thus displacing the present use of sailing vessels.

SCHOONER PRETORIA.—At Davidson's yard, West Bay City, Mich., on July 26, was launched the *Pretoria*, said to be the largest wooden merchant ship ever built. She is 350 ft. long, 45 ft. 6 in. beam, 27 ft. deep, and is intended to carry 5,000 gross tons of ore, or 175,000 bushels of wheat.

IMPROVED APPARATUS.

Vertical Duplex Boiler Feeder.

The vertical duplex boiler feeder herein illustrated is sometimes known as the "Admiralty Style." All parts are made very heavy and the bolting is unusually strong to withstand the high steam pressure necessary for driving modern multiple expansion engines. The piston rods are of Tobin bronze and the cylinders are lined with the same metal.

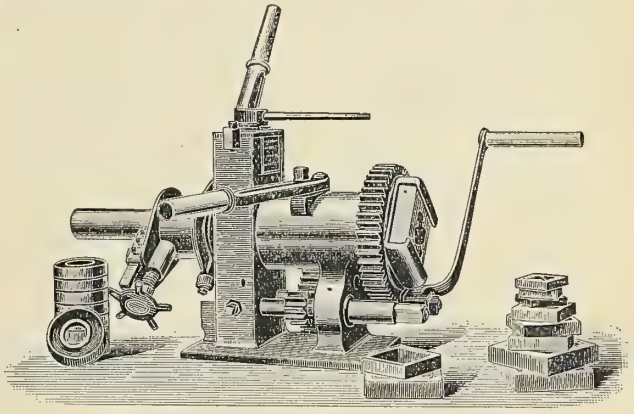


DUPLEX BOILER FEEDER.

The valve levers and rock shafts are of steel and no expense has been spared to make it a high quality pump. Pumps of this type are installed in places where floor space and head room are limited, where light weight is desired, and at the same time strength for working up to a pressure of 250 lb. per sq. in. The pump piston may be examined and repacked through the upper cylinders heads without disturbing permanent joints, piston rods or valve movement. This pump is manufactured by Dean Bros. Steam Pump Works, Indianapolis, Ind.

Pipe Cutting and Threading Machine.

The machine here illustrated and known as the Douglas patent pipe cutting and threading machine has been especially designed to meet rough and hard treatment at the hands of the unskilled labor usually employed for such operations. Ample strength and simplicity of construction are supplemented by compactness of design and a minimum of weight compatible with the strength required. Its weight complete with all its dies, guides, etc., is but 75 lb., and is therefore readily carried about and set up where most convenient to the work in hand. It is fitted with two

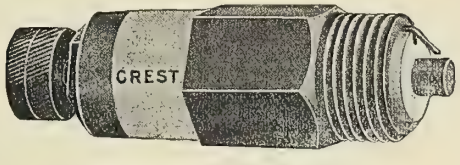


PIPE CUTTING AND THREADING MACHINE.

speeds of which the faster one can be used to "back off" after cutting a thread on a large pipe with the slow speed, thus effecting a saving of time. The machine will cut off and thread pipes from 1-4 in. to 2 in. inclusive, will cut long screws and close nipples, and is furnished with a complete set of solid dies and the necessary guides for that range of sizes. This machine is manufactured by P. Hollingsworth Morris, 1501 South Front St., Philadelphia. Pa.

The Crest Indestructible Sparking Plug.

It is well known that the sparking plug of gasoline motors is a delicate piece of mechanism often giving considerable trouble, and that the failure of motors can often be traced to the failure of this part of the apparatus. Although the jump spark method is the most largely used to-day on account of its simplicity, it would be universally used in preference to the contact and wide spark methods, if it was not for its liability to crack under the intense heat of the motors, short circuiting the secondary circuit.



THE CREST SPARKING PLUG.

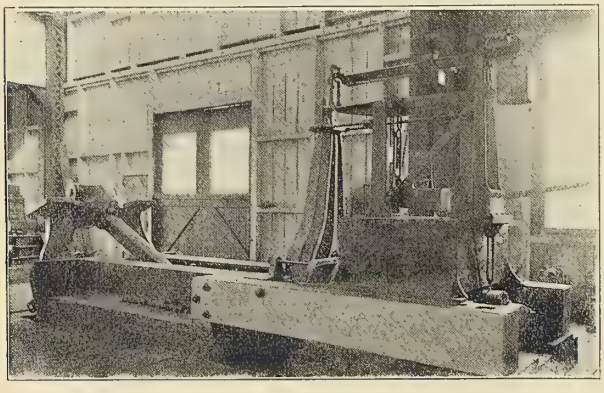
The Crest Manufacturing Company of Cambridgeport, Mass., manufacturers of Crest Motors for automobiles have recently put on the market a radically new design of sparking plug that is not affected by heat and expansion, and is consequently unbreakable. After considerable expense in experimenting with the best porcelain of foreign manufacture, they have, through the assistance of a well-known chemist, dis-

covered a new material that is unbreakable by heat or expansion. Sparking plugs made of this material have now been in use for a long time on their motors without reports of failure, and they have decided to introduce them to other manufacturers, and to the users of other makes of motors. The material used in this plug is a perfect electrical non-conductor and does not expand under intense heat. It is a soft tough material, not being brittle like porcelain. The sparking plug as shown in the cut consists of a shell of steel having a thread at one end to screw into the orifice in the motor chamber. The sparking plug proper consists of a small cone of this new material which is inserted in the steel plug. This cone fits tight in the shell, making a gas tight joint without packing, thus making the plug proof against carelessness in the hands of unskilled persons. Through this cone a wire with an enlarged head is passed, terminating at the bottom of the plug. A platinum wire is inserted in the body of the steel shell, the spark jumping across between the two points.

These plugs are sold singly or in lots of 25 to 100 to the trade.

Anchor Testing Machine.

About 100 years ago the anchor testing machine was first adopted by the British Admiralty, for the purpose of putting a pre-determined strain on a finished anchor to determine its soundness. The apparatus was crude in form, but served the purpose and the system of testing anchors has been kept up continuously ever since and has been officially approved by Lloyds Register. The anchor testing machine shown in the engraving has been constructed for the Baldt Anchor Co., of Chester, Pa. The anchors made by this company are of open hearth steel, and the castings are first annealed for seventy-two hours, after which the coupon is removed and tested. If this is satisfactory the anchor is suspended over an iron plate embedded in a concrete block and dropped a distance of 15 to 20

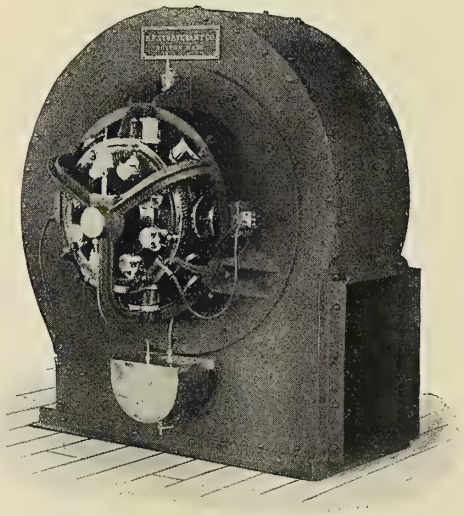


ANCHOR TESTING MACHINE.

ft., according to its weight and size. Having passed this test satisfactorily the anchor is then subjected to hammering as a further test of unsoundness. If all these tests are satisfactory to the inspector, the anchor is fitted up complete and subjected to test in the machine shown in the cut. The machine is capable of registering a pull of 350,000 lb., and by its means any desired stress may be put on the anchor in order to finally test it as a complete structure. A large stock of anchors thus tested is kept on hand by the Baldt Anchor Co., and they are thus in a position to supply at short notice anchors of any size and according to any test required.

Steel Plate Electric Fans.

The electric fan herewith illustrated has been designed with a special view to compactness. The shell is of steel plate, and upon its closed side is bolted a cast iron plate carrying three lugs, within which is centered and held the eight pole Sturtevant motor.



STEEL PLATE ELECTRIC FAN.

The field ring and cores of the latter are of wrought iron, the pole shoes being of cast iron, and of such shape and size as to render the machine capable of extreme variation of load without sparking at the brushes, and without necessity of adjustment.

The field coils are thoroughly insulated and machine wound, and are mounted on cores from which they may be readily removed. The open construction presents a great amount of radiating surface, thereby preventing the accumulation of heat. The armature has been carefully designed with special reference to low speed and high efficiency. Laminated slotted discs mounted on a cast iron spider form the core. These discs are solidly clamped between brass rings which support the edges of the core and protect the teeth from being damaged or misplaced, while presenting a smooth and well rounded corner for the support of the slot insulation.

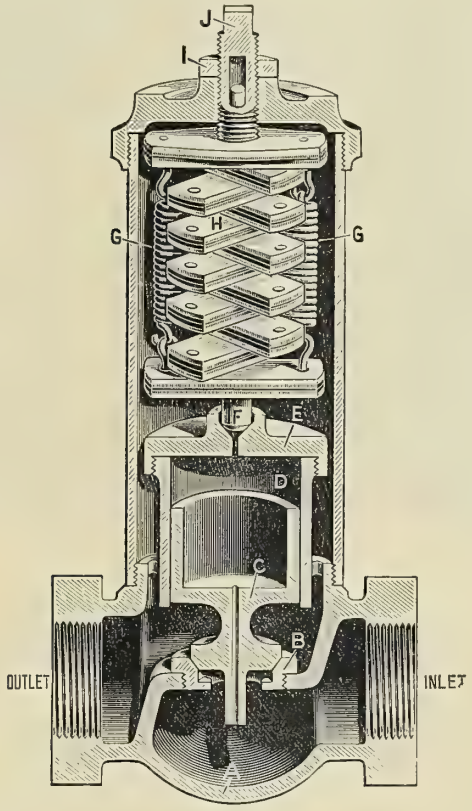
The construction of these cores and the manner of applying the coils is such that all parts are thoroughly ventilated, so that there is no danger of overheating, even when considerable overloads are carried.

The commutator is of large diameter, and consists of pure rolled or drop forged copper segments, supported in a cast iron shell of spider construction. Carbon brushes are used, and are supported upon a special rigging which is carried by brackets attached to the field ring.

A spider attached to each side of the field ring forms at its center a journal box which is provided with oil reservoir and ring oiler. The entire apparatus is designed and built by the B. F. Sturtevant Co., of Boston, Mass.

Thermostatic Steam Trap.

In this trap the adjustment is made according to the temperature at which it is desired the discharge shall take place. The condensation enters the body of the trap A, and passes through a small opening in the piston valve C into the cylinder D, thence through an opening in E into the thermostatic chamber, whence



THERMOSTATIC STEAM TRAP.

it drains back into the outlet side of the trap. If the opening in the piston valve is insufficient to carry off the condensation, the valve itself will rise and discharge to its full limit. Should steam or water at a higher temperature than that at which it is wished to discharge enter the thermostatic chamber, the bars H will become expanded and thereby cause the pilot valve F to close, thus shutting off escape from D, and forcing the piston and valve C to close down on the seat D, thus closing the trap against all discharge.

It is claimed for this trap that it will work equally well under high or low pressure, that it will discharge against any pressure less than the head pressure, and that it can be placed on a line of pipe like an ordinary valve, thus requiring no extra support. The seat is removable and the valves can be reground without removing the body of the trap from the pipe. The internal parts may also be removed without taking the body of the trap from the pipe and without the remaking of joints. It is also claimed that the thermostatic bars are sufficiently sensitive to insure prompt action both in discharge and closure, thus avoiding the unnecessary waste of steam.

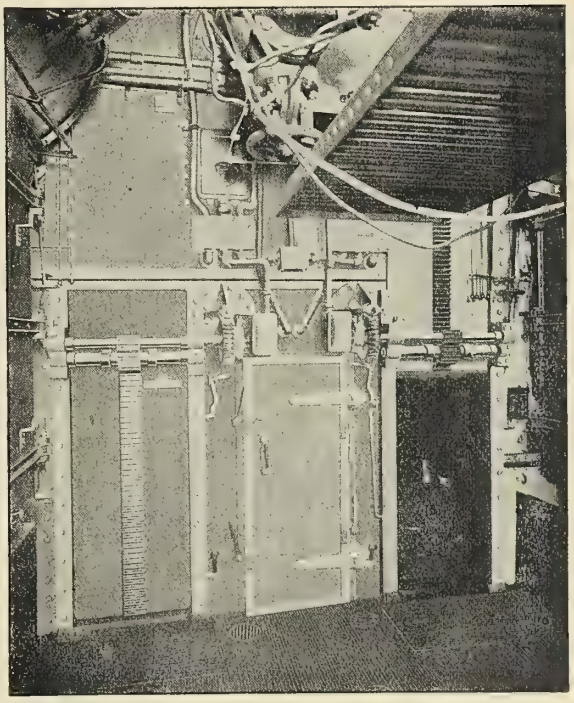
This appliance is known as the Bickel Steam Trap and is kept in stock in sizes from 1-2 in. to 2 in. inclusive by the General Sales Agent, Charles Bond, 520 Arch St., Philadelphia, Pa.

Safety Electric Water-Tight Doors.

No feature of a modern ship stands closer to the question of safety than water-tight sub-division, and the efficiency of the latter is almost entirely dependent on the prompt and reliable operation of the bulkhead water-tight doors which seem to be found a practical necessity in the actual operation of the ship, whether of the naval or mercantile marine. Three systems of power operation for such doors have been proposed, hydraulic, pneumatic and electric. The electric system herein illustrated is the result of the study given to this problem by Naval Constructor Francis T. Bowles, U. S. N., aided in the development of the electrical features and details by the Sprague Electric Co.

The following schedule of points are claimed for the system.

First. The door can be raised or lowered by power, or by hand, by one operator at the door on either side of the bulkhead.



U. S. S. ATLANTA, FITTED WITH ELECTRIC WATER-TIGHT DOORS.

Second. It will close either against the rush of water, or against a rush of mixed water and coal, or through coal on the door sill due to the first opening of a full bunker.

Third. It is possible to close by power from the bridge, or from one or more central or emergency stations, any desired group of doors, or all the doors simultaneously, or in any degree of succession.

Fourth. There is at each emergency station a positive and reliable indicator by which the closure of each door is made known.

Fifth. The operation of the emergency closing in no way interferes with the local operation by hand or power.

Sixth. The local control by power has precedence over the emergency closure, so that independent of such closure a door may be stopped or opened for egress. After the local switch is released the emergency again assumes control and closes the door.

Seventh. The leads which supply power, and which control the doors as well as the operating mechanism, are unaffected by any temperature conditions existing on board ship.

Eighth. The doors have no tendency to "creep," and will remain in any position without expenditure of power to hold them.

Ninth. The power is taken from the main generating plant of the ship, and requires no auxiliary central station or apparatus under continual and wasteful operation.

Tenth. There are no valves, springs or packing, subject to continual deterioration and requiring constant care.

The fulfillment of such a schedule would seem to indicate a successful solution of most of the problems connected with the power operation of water-tight doors. The system has been subjected to careful test at the Brooklyn Navy Yard, and has been installed on the U. S. S. *Atlanta*, S. S. *St. Paul* and other ships of the naval and mercantile marine. Further particulars may be obtained by application to the Sprague Electric Co., of New York.

High Pressure Packing.

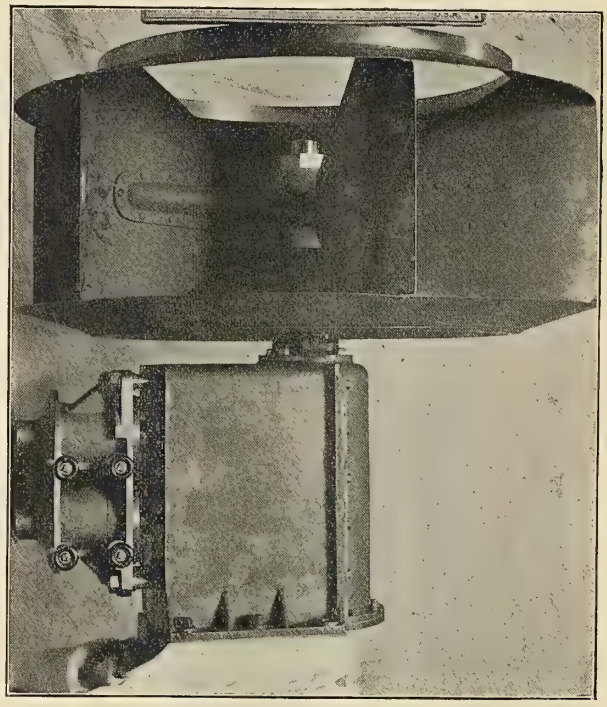
The continued demand for high grade packing for higher pressures, higher temperatures and higher speeds, to meet the requirements for all types of modern fast running engines, has caused the production of a packing which is designed to meet all these requirements. The packing shown in the illustration is known as No. 200. It is manufactured of selected fiber and

HIGH PRESSURE PACKING.

metal in combination with the well known Garlock packing compound. No. 200 packing has been used on a large number of engines in the most extensive stationary plants in the country, and also on compound, triple expansion, and quadruple expansion, marine engines, in many instances with 200 lb. pressure, and invariably with satisfactory results. It is manufactured and sold by the Garlock Packing Co., Palmyra, N. Y.

High-Speed Ventilating Engine.

Careful examination into the causes of failure in engines only too often shows that it is due initially to the failure of some small relatively insignificant part of the machine. A 3-8 in. set screw shears or drops out, or some other like insignificant part is the starting point of the whole trouble. In fact it is fair to assert that in the majority of cases small details and not the



HIGH-SPEED VENTILATING ENGINE.

main designs are responsible for the failure. Many steamship engineers assert that the main engines, developing enormous horse power, give comparatively little trouble as compared with the auxiliaries in the shape of blowers, pumps and circulating pump engines, etc., etc., which develop probably in comparison but a "few mouse" power. It is therefore a matter of great importance to have auxiliary engines which will run continuously for long periods of time, and without danger of heating, breaking down, etc. With this end in view the engine which is illustrated herewith was designed. It is either a horizontal engine set up on edge, or a vertical engine laid down on end, as one may choose to select. The shaft runs vertically and the cylinders two in number are at right angles to it. The oiling of the engine is accomplished by a small pump which forces the oil through the crank shaft to all the bearings including the guides and crosshead pins. This oiling system demands practically an enclosed engine which detracts somewhat from the appearance and adds somewhat to the weight of the engine and its first cost, but these features are so entirely offset by the certainty of lubrication that they are not to be considered as objections.

This engine is built by W. D. Forbes & Co., of Hoboken, N. J., and is one of a lot sent to the W. R. Trigg Co., Richmond, Va., for U. S. Navy torpedo boats.

The Taylor White Process for Treating Tool Steel.

One of the most notable features of modern industrial progress is found in the great reduction in the time required for productive and manufacturing operations. In all operations requiring the shaping of metals the problem resolves itself into two parts: (1) the production of the piece in the rough of such dimensions and form as to require the minimum amount of material removed for finishing, and (2) the removal of this material in the minimum of time. A most notable advance in the latter feature has recently been made possible by the "Taylor White" process for treating tool steels. This process is the result of a special investigation on the part of Messrs. F. W. Taylor and Maunsel White of the Bethlehem Steel Co. From a description of the process recently given to the public, the following points are abstracted:

A special lathe was set aside for the purpose of experimenting with tool steels of different makes with a view to the selection of a standard for use, and several picked men were set to work testing the relative merits not only of the different tool steels then in the shop, but of all brands of established reputation.

In the tests of these various makes of tool steels over 200 tons of steel forgings were cut up into turnings, and it is estimated that over $100,000 was expended in labor and material alone in developing this process. This large investment, however, was more than repaid in the first year by the saving in labor cost, and larger output in the shops. The increase in the cutting speed of the various machine tools throughout the shops has entirely reversed the inequality of balance formerly existing between the forge and machine shops, so that the capacity of the former has had to be largely increased in order to keep pace with the rapidly growing efficiency of the latter. The introduction of this process has made it possible to speed up the main line of shafting in the machine shop from 90 to 250 revolutions, and further changes in counter shafts have been made to give still greater speed to individual machines.

From a large amount of data the following results are reached: The average cutting speed has been increased from about 9 ft. per minute to 25 ft. per minute, or a gain of about 180 per cent. The average depth of cut has likewise been increased from .23 in. to .30 in. and the feed from .07 in. to .087, making an increase in the cross sectional area of the chips of about 60 per cent. This combined with the increase of cutting speed gives the relative weights of metal removed in the ratio of about 4.40 to 1, or an increase of about 340 per cent.

One of the especial features of this process is that it gives to the steel the very valuable and exceptional property of retaining a high degree of hardness when heated to a visible red heat. It is possible with one of these tools to cut steel at a speed so great as to heat up the point of the tool to redness and have it continue to cut for several minutes at this speed, leaving an unusually smooth finish on the work, as well as cutting accurately to size. The effect of the process which is applied after the tool has been dressed or machined to shape penetrates to the center of the steel, even in the largest tools treated, i. e., 4 in. square. All the standard brands of self hardening steel which have been experimented with are improved to a greater or less extent by the treatment. It is preferred, however, to us a steel of special composition in order to get the greatest uniformity and maximum results. This special steel forges so much more readily than the general run of self hardening steels that tools of different shapes may be easily made up. A simple and comparitively rapid method of annealing the special steel has also been discovered by which tools may be easily machined to shape, making it applicable to twist drills, chasers, inserted cutters, etc., tools which have heretofore not been made of self hardening steel.

A further important feature resulting from the use of this process is that the tools are extremely uniform in quality, so that work on which they are used can be readily performed at the maximum rate of speed.

LAUNCHES—HOME AND FOREIGN.

S. S. Sonoma.—The steamship *Sonoma*, built for the Oceanic Steamship Co., was launched at Cramps yards on Aug. 7. The *Sonoma* is intended for the trans-Pacific trade between San Francisco and Australia, and is of the following dimensions: Length, b. p., 400 ft.; beam, 50 ft.; load draft, 24 ft.; displacement, 9,700 tons. The designed I. H. P. is 7,500 and the contract speed is 17 knots. The ship is provided with accommodations for 400 passengers. The ship is one of three for the same line, the first, the *Sierra*, was launched in May, and the last, the *Ventura*, is nearly ready to leave the ways at the present time.

Schooner George W. Wells.—At Camden, Me., at the yard of H. M. Bean, the six masted schooner *George W. Wells* was recently launched. The dimensions of the *Wells* are as follows: Length on keel, 302 ft. 11 in.; length on top, 345 ft.; beam, 48 ft. 6 in.; depth, 23 ft. The net register tonnage is 2,750 tons, and the carrying capacity upwards of 5,000 tons. This schooner is the largest ever built for ocean traffic, and marks a further step in the development of the type as large freight carriers. She is fitted with a 30 H. P. steam windlass, and with pumps having a combined capacity of 1,200 gallons per minute. Her spread of sail is about 12,000 sq. yds.

S. S. Empress.—This steamer was launched on July 21 from the yard of A. D. Story, in Essex, Mass. She was built for the Beverly Transportation Co., and is intended for service between the mainland and Bakers Island. Her chief dimensions are: Length, 60 ft.; beam, 16 ft. 6 in.; depth, 5 ft. 6 in. She will have a gasoline motor for power and is intended to have a speed of about 8 knots. Her carrying capacity is 125 passengers.

Schooner Wm. C. Carnegie.—On Aug. 14 at the yard of Percy & Small, Bath, Me., was launched the five masted schooner *Wm. C. Carnegie*. The *Carnegie* has the following principal dimensions: Length 289.2 ft.; beam, 46.3 ft.; depth, 22.4 ft.; gross tonnage, 2,663.99; net tonnage, 2,380.93; carrying capacity, 4,500 tons. The vessel was launched, rigged and ready for sea. Her cost was about $115,000.

MARINE ENGINEERING

PUBLISHED MONTHLY

BY

ALDRICH & DONALDSON,

309 Broadway, New York.

Editorial Department,
H. F. DONALDSON.

Business Department,
H. L. ALDRICH.

Branch Offices,

Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Detroit, Mich., Hodges Building, L. L. CLINE.
Chicago, Ill., Monadnock Block, S. W. HUME.

TERMS OF SUBSCRIPTION,

	Per Year.	Per Copy.
United States, Canada, and Mexico.....	$2.00	20 cents.
Other countries in Postal Union....	2.50	25 cents.

Entered at New York Post Office as second class matter.

Notice to Advertisers.

Copy for changes in advertisements must be in our hands not later than the 20th of the month to insure changes being made in the issue of the month following, and not later than the 15th of the month if corrected proof is to be submitted.

AS we approach the last months of the century now drawing to a close, it is not unnatural to think of the future, and of what it may hold in store for those who go down to the sea in ships. The progress during the past century has been so absolutely revolutionary in character and far reaching in its results that it is perfectly safe to say that no human intelligence a hundred years ago could have foreseen the developments with which we are to-day familiar. It would doubtless be equally vain to attempt to forecast the developments of the century upon which we are about to enter. It may be, however, not without interest to take account of stock, so to speak, and to note at least for the engineering features of the problem the directions along which we may look for signs of future progress, leaving aside of course developments so revolutionary in character as to be entirely out of sight from our present standpoint.

In the first place there is nothing in sight which seems likely to displace some form of steam boiler and engine for the development of power.

If then the steam boiler is to be our reliance, at least for the immediate future, interest attaches to the question of type. Whether the boiler of the future will be shell or water tube, or whether both will persist as rivals, can now perhaps be only a matter of opinion. When we consider, however, the advances made by the water tube boiler in the last decade, especially in the Naval Marine, and remember its variability of form, its ready adaptability to high pressures, and saving of weight over its shell rival, it is not too much to say that in the minds of many the finger of progress points by way of this boiler, not necessarily or indeed probably by any of the types now existing, but more probably by some one or more types which shall result from the study now being expended on this problem.

As to the means by which the energy of the steam shall be transformed into mechanical work, we now see the field occupied by the common type of steam engine in which the reciprocating motion of the parts acted on by the steam is transformed into rotary motion of the shaft. A rival has, however, appeared in the steam turbine, a motor in which the parts acted on by the steam move in a rotary path at first hand, and hence simpler in many ways than the usual type of engine, and avoiding many of the difficulties due to the existence of reciprocating motions in its parts. The steam turbine, however, is far from being a perfected motor at the present time, and it is yet too early to say what shall be its share in the future development of marine propulsion. It seems not too much, however, to hazard the opinion that the role to be played by this form of motor is likely to be one of increasing importance. In no part of the field during the past one or two decades has the progress been more significant than in the reduction of weight of machinery per unit of power developed. A continuance of this reduction must depend on several factors: (1) The use of higher mean effective pressures. (2) The use of higher piston speeds. (3) The development of materials of greater strength for the same weight, and (4) The better use of such materials as we have, through greater care and improved design. In regard to higher steam pressures it is probable that boiler pressures will continue to increase up to a limit which can hardly be set at the present time. A corresponding increase in mean effective pressures is less likely, however, as this would tend to sacrifice the gain in efficiency due to higher boiler pressures. The piston speeds in use may be expected to gradually increase with improvements in materials and methods of construction, though it

would hardly seem justifiable to expect very rapid advance in this feature.

The outlook so far as new materials are concerned is not especially promising, and it seems likely that saving of weight must be attained chiefly by a better use of those already available. In this direction we may look with confidence for considerable advances.

Regarding the cost of power in terms of coal we may look for a slow and continuous decrease. Any such advance in this direction as has been attained during the past century is, however, entirely out of the question, except with some entirely new method of power development. As the steam engine now is, we are rapidly approaching the limit of the possible in regard to its efficiency, and naturally further progress will be at a slower and slower rate. The greater progress here will result from the studious effort to bring the average up to the present exceptional practice. In rare cases we have records of one I.H.P. per pound of coal per hour. This is already attainable therefore, and the problem immediately before us is to make such records the rule rather than the exception, and this without too serious a sacrifice of other desirable features of design.

For the actual instrument of propulsion there is certainly nothing in sight which seems likely to displace the screw propeller. We may go a step farther and say that in itself the screw propeller is susceptible of very little improvement. What is needed here, and what we may look for the future to supply, is a better understanding of the operation of the screw propeller and of its adaptation to special cases, so that we may be sure of always obtaining a propulsive efficiency not sensibly below the highest possible.

A FEW months since reference was made in these columns to the troubles which the British Admiralty were having in connection with the wholesale adoption of the Belleville boiler in warship design. Apparently a further stage has been reached and it is announced that the whole question is to be made the subject of inquiry on the part of a Board of Experts acting under Parliamentary authority. In the meantime the claims of the Scotch boiler are finding most doughty champions in Sir Fortescue Flannery and Mr. Allan, and Mr. Goschen will apparently need all the resources of his position to satisfactorily meet the criticisms which are made on the policy of the Admiralty in committing themselves so entirely to one type of boiler for the powering of large warships. Happily our own Engineer-in-Chief, Rear Admiral Melville, while coming out decidedly for the water tube boiler as a type for naval purposes, is far from pinning his faith to any one variety, and we may therefore with good reason hope that in the experience which may follow from this policy, results will be found which will go far toward showing what characteristics must be considered as necessary in the water tube boiler best suited to the needs of the Navy. The same experience should also aid in the consideration of the problem of the best boiler for the Mercantile Marine—whether here the Scotch or tank boiler is still preferable as of old, or whether the time has come when the water tube type may with advantage be adopted for certain Mercantile purposes. The experience with the larger American Naval vessels now being fitted with various types of water tube boilers will be watched with the keenest interest by all who are interested in the future of the Marine boiler.

WE give on another page a brief note relating to the financial report of the American Shipbuilding Co. for the past fiscal year. Earnings for what is practically the first year of its operation representing seven per cent on a capitalization of about $15,000,000 indicate a lively condition of lake shipbuilding, and excellent management on the part of the company's officials. How such gross earnings may compare with what might have been earned with the various yards under separate management, as before the consolidation, is, of course, wholly a matter of conjecture; but it is probably not too much to believe that future years, with a like prosperous condition of trade, will show results still more satisfactory to the stockholder than those for the first year's operation. In the meantime the various yards have a large number of vessels in hand and several more in prospect. A visit to the yards on the Atlantic coast and on the Delaware shows likewise a most astonishing amount of work in hand and in prospect. Whatever may be the conditions most favorable to the advance of our mercantile marine, business confidence in ships and shipping as an investment is certainly one of those most immediately essential, and, if the present condition of our yards may be taken as a proper index, it would appear that we are approaching a healthy condition of confidence on these points.

THE STEAM ENGINE.

AN ELEMENTARY DISCUSSION OF THE PRINCIPLES WHICH GOVERN THE ECONOMICAL USE OF STEAM FOR THE DEVELOPMENT OF POWER—I.

BY DR. WILLIAM FREDERICK DURAND.

In the following discussion it will be assumed that the reader has a general knowledge of the chief properties of steam and of its relation to the heat which it contains. We will then take up in an elementary way a discussion of the principles governing its economical use in a steam engine.

At the very outset it must be clearly understood that we derive the work of the engine from the heat which the steam contains, and not from the steam in itself. The steam is simply a carrier for the heat and the operation of the engine is simply a means for transforming into useful work a fraction of the heat which comes into the engine, and then rejecting the remainder with the steam which is its carrier. The larger the fraction of the heat which can be transformed into useful work the better the efficiency of the engine, and the constant aim is therefore to turn into useful work the largest possible fraction of the heat which enters with the steam.

It may be asked, why not turn all the heat into work, and so realize a perfect efficiency? Unfortunately a series of natural laws and limitations seems to prevent all hope of realizing such an ideal, and actually we must be content with turning into useful work a comparatively small fraction of the total heat supplied. First and foremost among the causes of this reduction in efficiency is a principle or law sometimes known as the second law of thermodynamics. This law fixes a limit on the fraction of heat which can be transformed into useful work, such limit depending on the extreme temperatures between which the substance is worked in the engine. Thus if t_1 is the temperature of the steam at admission and t_2 that at exhaust, so that t_1 and t_2 are the two temperatures between which the steam is worked, and $(t_1 - t_2)$ is the range, then the law asserts that no engine, no matter how perfect, can transform into useful work a fraction of the entering heat greater than $(t_1 - t_2) \div (t_1 + 461)$. As another way of stating this relation, the temperature may be supposed to be measured from a point 461 or more accurately 460.7 degrees below the ordinary zero of the Fah, scale. This is called the *absolute zero*, and temperature measured from this zero is called *absolute temperature*. The difference of the temperatures would be the same no matter whether measured from the ordinary or absolute zero. The numerator of the above fraction is therefore the difference or range of temperature, while the denominator is the absolute temperature of the entering steam. The fraction of heat converted into useful work can therefore never exceed the *temperature range* divided by the *absolute temperature of the entering steam.* Thus to illustrate suppose that $t_1 = 370$ and $t_2 = 140$. Then the fraction becomes $(370 - 140) \div (370 + 461)$ or $230 \div 831 = .277$ or slightly over one-quarter.

These figures represent the limits for steam of about 160 lbs. gauge pressure, and it therefore appears that for engines operating between these limits this law steps in, and at one stroke reduces the ideal efficiency from one to about one-quarter; or in other words we are forced, due to the operation of this law, to throw away about three-quarters of the total heat, and at the very best with the most ideally perfect engine could only transform into useful work the remaining one-quarter.

Such then is the very best that could be done by a so-called *ideal* engine. The working substance in the simplest form of such an engine must be carried through a series of changes or operations, four in number, and specified as follows:

(1) The first operation must consist of an expansion at constant temperature, and all heat received from the source of supply must be received during this operation.

(2) The second operation must consist of an expansion with decrease of temperature during which, however, no heat as such is allowed to either enter or leave the substance.

(3) The third operation must consist of a compression during which the temperature remains constant and all heat removed from the body must be removed during this operation.

(4) The fourth operation must consist of a compression with increase of temperature, during which, however, no heat as such is allowed to either enter or leave the substance, and at the end of which the substance must find itself in the same condition as at the beginning of number (1).

Work is done by the substance during operations (1) and (2) and work must be done on the substance during (3) and (4). The difference between the work done *by* and *on* the substance will be the net work obtained from the heat in the substance, and the ratio of this to the total heat supplied during number (1) or the efficiency of the engine will be exactly measured by the difference between the temperatures of operations (1) and (3) divided by the larger increased by 461; or in symbols:

$$\text{efficiency} = \frac{t_1 - t_2}{t_1 + 461}$$

This is then the cycle and the efficiency of an ideal engine in the simplest form. There may be certain related variations in operations (2) and (4) making a more complicated cycle, but with the same efficiency. This ideal marks, then, the highest possible limit of efficiency for any and all engines working between the given temperature limits t_1 and t_2.

In Table I are shown the values of this limiting efficiency for engines with gauge pressure as indicated, all condensing and supposed to have a back pressure of 2.8 lbs. absolute, or a lower temperature, t_2, of 140°.

An examination of this table shows that with the ideal conditions which correspond to the operation of this engine, the fraction of heat utilized with modern boiler pressures would range from 25 to 30 per cent. These conditions, however, are far from those which actually exist in practice. Every one of the conditions specified above is violated in greater or less degree, and the result is that with the operation of the engine under the best conditions obtainable in actual

practice, the fraction realized will be only some 60 to 80 per cent of the figures for the ideal case as given in the table below. These figures, 60 to 80 per cent in the best practice, really measure the efficiency of the engine so far as the engineer is responsible. That is, nothing which he can do will serve to avoid the loss which reduces the limiting efficiency down to

TABLE I.

Gauge Pressure at Engine.	Limiting Efficiency.
100	.248
110	.253
120	.259
130	.264
140	.269
150	.273
160	.278
170	.281
180	.285
190	.289
200	.292
210	.295
220	.299
230	.301
240	.304
250	307

that for the ideal engine as given in the table above. His efforts are therefore limited to approaching as nearly as possible to the conditions of the ideal engine, and the figures 60 to 80 per cent measure the degree of approach which modern engineering practice has made to this ideal. Thus for illustration if the ideal engine could transform 25 per cent of the heat into useful work, a good actual engine working between the same temperature limits will be able to transform from 15 to 20 per cent, and similarly for other conditions.

To put the matter a little differently, any and all engines fail to transform into work all of the heat supplied to them. In the ideal engine as specified above, the part not transformed but rejected as heat is the least possible for all engines working between the same limits of temperature t_1 and t_2. In any actual engine the amount not transformed into work but rejected as heat is greater than in the ideal case. Such *additional* amounts of heat rejected and not transformed into work are called *wastes* or *losses*. That is, all differences between the performances of the ideal and actual engines are considered to be due to these so-called *wastes* or *losses*.

These various wastes may be classified as follows:

(a) *Radiation and Conduction Waste.*

This consists of heat which is radiated away from the hot surfaces of the cylinder, or conducted away through the columns and bed plate. The heat thus escaping avoids transformation into work and is therefore counted as a heat waste, or as an expense from which no corresponding return is received.

(b) *Initial Condensation.*

At the instant the steam valve opens, the steam rushes into the cylinder to find itself in contact with surfaces which have but recently been exposed to the influence of the condenser or external air. They are, therefore, at a temperature much lower than the steam, and in consequence a part of the heat is absorbed and a corresponding part of the steam is condensed. The heat thus absorbed by the surface of the cylinder and piston will be given up later during the exhaust period of the revolution, and thus communicated to the condenser. It thus appears that a thin skin of metal on the inside of the cylinder and on the faces of the cylinder head and piston may be considered in a sense as a place of hiding into which a portion of the heat slips on the entrance of the steam, and from which it escapes to the condenser or air without having taken part in the cycle of the engine, and hence without having contributed its part to the useful work done. The heat so escaping appears thus as an expense, but without any corresponding return in work, and therefore constitutes a heat waste.

(c) *Irregularities of the Cycle.*

We have specified above the four fundamental operations of the ideal engine cycle in its simplest form. In the actual engine none of these is realized, and the variations are all such as to count against the efficiency. Into the details of these points we cannot here enter, and the broad statement must suffice that with but few exceptions, the variations from the routine specified above for the ideal engine will count against the efficiency and occasion a heat waste greater or smaller as the circumstances may determine.

The Improvement of the Steam Engine. From the preceding section it follows that there are two fundamental methods open for the improvement of the steam engine from the standpoint of economy.

(1) An increase in the temperature range and thus an increase in the ideal or limiting efficiency.

(2) The saving of some of the various wastes as noted above.

The first raises the ideal efficiency and hence with a given proportion of wastes will raise the actual efficiency as well. The second raises the actual efficiency by carrying it a little nearer to the ideal.

The temperature range may be increased in two ways,—the initial temperature can be raised, and the final temperature can be lowered.

The continually advancing pressures in modern practice means a constant rise in the upper temperature, a constant increase in the ideal efficiency, and with the same proportion of losses, a corresponding rise in the actual efficiency. This is then the real significance of high pressures in modern practice so far as they are related to the question of economy.

Again by decreasing the back pressure from say 18 lbs. for a non-condensing engine to say 3 lbs. for a condensing engine, a very considerable decrease in the final temperature is obtained, a corresponding increase in the temperature range, and a resultant increase in actual efficiency. This is likewise the real significance of the influence of the condenser on the economy of the engine.

In general then, the proportion of heat wastes being the same, the economy will be better as the initial pressure is higher, and the back pressure is lower; or in general, as the range of pressure and temperature worked through is the greater.

We may turn next to the problem of reducing the wastes of the actual engine, as specified under the three heads above.

The waste due to radiation and conduction cannot be wholly avoided, but the former, which is by far the larger of the two, may be much reduced by suitable lagging or non-conducting covering. With such provision the loss under this head is usually very small compared with the other losses mentioned.

The waste due to the so-called initial condensation is one which may be reduced, but not wholly avoided. Before discussing the means suitable to this end some further explanation of the nature of the loss will be required.

As already pointed out, the action of the metal walls in producing this loss depends on their capacity when at a lower temperature, for absorbing heat from the steam (as during admission) and for giving it up when at a higher temperature (as during exhaust). The action depends, then, on the range of temperature between admission and exhaust, and on the particular readiness with which the walls absorb and reject heat according as they are cooler or hotter than their surroundings. There are therefore two distinct features to be considered—the range of temperature, and the readiness with which the iron absorbs and rejects heat under the conditions mentioned.

Now it is found that if the expansion through the entire temperature range is split up into a series of steps, each carried out in a cylinder by itself, the loss under consideration is less than if the entire expansion should take place in one cylinder. Carrying out this principle we have, of course, the multiple expansion engine with its total range of operation divided among several cylinders in series.

This, then, is the real significance of the multiple expansion (compound, triple, quadruple, etc.) engine, so far as its relation to economy is concerned—the splitting of the total expansion or of the total temperature range into a series of steps is found to reduce considerably one of the wastes, and so raise the actual efficiency of the engine.

Next turning to the other controlling feature of this loss,—the readiness of absorption and emission—it seems to be the case that once the internal surfaces become wetted or covered with a film of moisture, the absorption and emission of heat into and from the metal proceed with much greater readiness than when they are dry. In other words the passage of heat between metal with a moistened surface and moist steam is much more rapid than between the same metal with a dry surface and dry or superheated steam.

In the ordinary steam engine we have, therefore, an action of the walls due to the range of temperature employed, and to the natural capacity for cast-iron or steel to absorb and emit heat from and to steam, greatly augmented by the presence of a more or less complete film or layer of water over the surface, arising from the condensation of the first entering saturated steam.

The use of superheaters, reheaters and jackets is found in a general way to decrease the readiness with which heat exchanges occur between the metal and the steam, and thus to decrease the amount of waste due to their actions. Thus in an engine using moderately superheated steam we should have the same general tendencies as noted above for the operation with saturated steam, but less augmented because of the smaller amount of moisture formed. In an engine using steam superheated to such an extent as to remain above the point of saturation during its entire passage through the cylinders, no moisture is formed and the action of the surfaces is limited to that which can take place between their dry surfaces and the dry superheated steam. The office of superheating is then simply to reduce the readiness with which the exchange of the heat between the metal surfaces and the steam is effected. The results show that in such case the reduction is real and productive of a considerable increase in economy.

Regarding the use of reheaters it seems likely that their beneficial action will be well marked in proportion as they are able to superheat the steam passing through them, and thus act as a superheater in stages, each for the cylinder next beyond.

The beneficial results gained by the use of steam jackets are in large measure due to action of the same character. The jacket containing steam at a temperature higher than that in the cylinder transfers heat into the inner surface of the cylinder walls and thus tends to keep it dry and to reduce the amount of heat exchange, and hence the corresponding waste. The steam jacket acts also to some extent to modify the character of the cycle as noted below, but most of its useful action may probably be put down to the hindering of heat exchanges between the walls and the steam in the cylinder.

It must not be forgotten, however, that whatever gain is thus effected within the cylinder is obtained at the expense of the heat drawn from the jacket, and the whole operation is therefore an attempt to reduce one loss by introducing another. If the latter is less than the saving in the cylinder, the net result will be a gain equal to their difference. If the latter is the greater of the two, the net result will be a loss, and if they are equal the net result will be no change in the economy of the engine. These relations account for the varying experience with jackets, but it now seems well assured that when properly fitted and operated, the result will show a gain of from 5 to 10 per cent over similar conditions unjacketed.

We come now to the last principal division of the wastes of the actual steam engine,—those due to irregularities in the cycle, or in other words to variations from the routine of operations which would give the efficiency of the ideal engine as discussed above. In this respect but little can be done to improve matters. The use of jackets and reheaters may possibly affect the routine in such a way as to bring it somewhat closer to the ideal conditions, but this is by no means certain, and the benefit due to these appliances comes mostly from the decrease in cylinder condensation as explained above.

There are methods, however, of modifying the cycle of the engine by the use of a series feed water heater, in such way as to bring it somewhat nearer to the ideal cycle. Such a feed heater for a quadruple expansion engine may consist of say three chambers or heaters through which the feed passes in series. In the first it is heated by steam drawn from the L.P. receiver. It then passes on to the second chamber, where it is heated by steam drawn from the second I.P. receiver, and then goes on to the third chamber, where it meets with steam drawn from the first I.P. receiver. As the feed water thus becomes hotter and hotter it meets with steam of higher and higher temperature drawn from the successive higher receivers in the engine, and it is thus brought nearly to the

temperature of the water in the boiler. The exhaust from pumps may also be turned into the first chamber, thus making it a means of taking heat from their exhaust and of returning it with the feed to the boiler. Various modifications may be worked out in the details of the operation of such feed heaters, but in all cases their significance lies in the fact that the cycle of operations as a whole may in this way be brought a step nearer to the ideal cycle than would otherwise be the case. All such changes, if made in accordance with the proper principles, may therefore result in a saving of heat and in a gain in the economy of the engine, and in this fact lies the chief significance of the feed-water heater as a feature of modern engineering practice.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XXIV.

BY WM. BAXTER, JR.

ELECTRIC LAMPS.

Several kinds of electric lamps have been devised, but of these the only ones in actual use are the incandescent and the "Arc" lamps. The former are used in all cases where it is desired to obtain a number of small lights, while the latter are employed in cases where a powerful illumination is required.

Incandescent lamps are so simple in construction and operation, that a brief description of them will be sufficient. The lamp consists of a thin strip of carbonized card board or some similar material, this being connected with metallic terminals through which connection with an electric circuit may be made. The passage of an electric current of sufficient strength through the carbon heats it up to the luminous point. The carbon filament is inclosed in a glass globe from which the air is exhausted as completely as possible, the object of this arrangement being to prevent the burning of the carbon. If the globe of an incandescent lamp springs a leak, the air entering through it immediately burns up the filament. Carbon is used for the incandescent filament, because its resistance is many thousand times as great as that of a metallic wire of the same size, and on that account the heat that is developed in it is correspondingly great. If the filament of an incandescent lamp were not of such high resistance, a sufficient amount of heat to raise the temperature to the luminous point could not be obtained without greatly increasing the strength of the current, and as the energy absorbed by a lamp is equal to the product of the current strength by the voltage, it follows that the latter would have to be lower than with a lamp taking a smaller current. Low voltage is not desirable because then the wires that carry the current to the lamps have to be made larger, hence, the effort constantly made by manufacturers is to increase the resistance of the lamps so as to be able to run with a higher voltage. A sixteen candle power incandescent lamp requires on an average about 55 watts of electrical energy to keep it burning up to the full rated power; the watts being the product of the volts by the amperes, it follows that a 50 volt lamp requires a current of about one ampere, and a 110 volt lamp a current of one-half of an ampere, while a 220 volt lamp would require only one quarter of an ampere. For marine purposes lamps are of either 110 volts or less.

Arc lamps are not so simple in construction nor in principle of operation as the incandescent. In this type of lamp the light is produced by the burning away of the ends of carbon rods, therefore, mechanism has to be provided that will feed the rods together as fast as they are consumed. The light developed by the

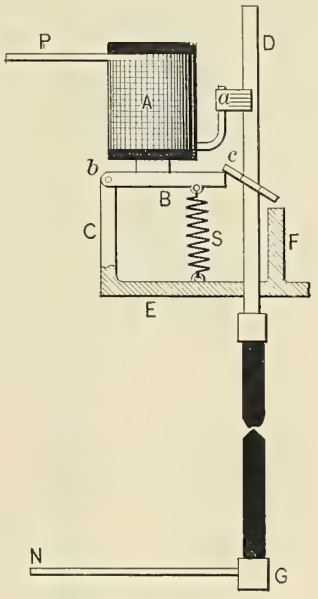


FIG. 157.

lamp is proportional to the distance between the ends of the carbon rods, that is, when this distance does not exceed a certain limit. If the rods are close together the light will be dim, and if they are far apart it will be bright, so that to maintain it at a uniform brilliancy it is necessary that the feeding mechanism be controlled by the distance between the ends of the rods, or by the length of the arc, which is the name given to the space that intervenes between the ends of the carbons.

The simplest form of arc lamp is shown in Fig. 157. In this illustration, *P* is the wire through which the current enters the lamp, and *A* is a magnet that is arranged so as to lift the lever *B*. This lever is pulled down by the spring *S*. After the current passes through magnet *A* it reaches a sliding contact through which it passes to the rod *D*, which carries at its lower end one of the carbons. The action of the lamp is as follows: When the current is not passing through the lamp, the two carbon rods, the one attached to *D*, and the one held in *G*, are in actual contact, the top one resting upon the end of the lower one. If the wires *P* and *N* are connected with an electric circuit, a current will pass on account of the carbon rods being in contact. As soon as the current passes the magnet *A* becomes energized, and lifts the lever *B*. This lever raises the clutch ring *c* and thus lifts the rod *D*, causing the ends of the carbons to separate and form an arc. Although the carbon ends have been separated, the current continues to pass, but as the resistance of the space between the

carbons is very great, an amount of energy is required to force the current across the gap that is sufficient to raise the temperature to a very high point, in fact much higher than that of a blast furnace, or any other artificial heat. As the carbon rods burn away, the resistance of the arc increases, and as a consequence the strength of the current reduces. The reduction in the strength of the current results in a reduction

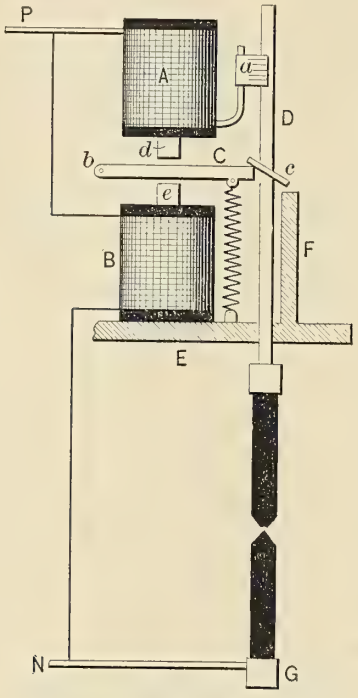


FIG. 158.

in the attractive force of the magnet *A*, hence, the pull of spring *S* is soon able to draw lever *B* downward. When *B* is drawn down a sufficient distance, the outer end of clutch *c* strikes the stop *F*, and the rod *D* is released, and slips through *c* until the carbon points come into contact. By this action the resistance of the arc is immediately reduced and the strength of the current is increased, so that once more the magnet *A* becomes strong enough to lift *B* against the pull of *S*.

The principle illustrated in this simple diagram is used in many designs of lamps actually manufactured, but the action is rendered more perfect by the addition of devices that prevent the rod *D* from moving too rapidly. It can be plainly seen that if the rod *D* can fall freely when it is released by the clutch *c*, its descent will not stop until the upper carbon comes into actual contact with the lower one; but if *D* can not fall freely, then it may not drop so far as to allow the carbons to come into contact, for as the rod descends the resistance of the arc decreases, and the current strength increases, and if *D* does not drop too fast, the current strength can increase sufficiently to enable magnet *A* to draw up lever *B* before the carbons come together.

Lamps constructed upon the principle of Fig. 157 cannot act if connected in series in the same circuit, because they depend for their operation upon the changing strength of the current. This type of lamp was used in the days when each light was operated by an independent machine, and it is also used at the present time for lamps that are operated from incandescent lighting circuits.

In order that a lamp may be able to operate in series with several other lamps it is necessary that the feeding of the carbon rods be controlled by the resistance of the arc, and not by the strength of the current, for with such an arrangement it is necessary that the current remain constant in strength. Fig. 158 illustrates the principle upon which lamps operate when constructed so as to work in series. In this diagram Fig. 157 is modified simply by the addition of a second magnet *B*. This magnet is traversed by a current that cuts around the arc; therefore, the coil is made of many thousand turns of very fine wire, so that the current that can pass through it is but a small fraction of that which passes through the arc. The operation of this type of lamp is as follows: When the light first starts up, the arc being short, its resistance is low, hence the current diverted through magnet *B* is so small that its pull upon lever *C* is much less than that of magnet *A*. As the carbons burn away, and the length of the arc increases, the resistance thereof increases, and the current through *B* is increased. In this way the pull of *B* gradually becomes stronger as the arc lengthens out, and finally the pull of *B* with the assistance of spring *S* becomes sufficient to overcome *A*, and lever *C* is drawn downward until clutch *c* strikes stop *F* and allows rod *D* to slip through. If the two magnets *A* and *B* are properly adjusted as to strength the spring *S* is not necessary, and in some of the lamps of this type it is not used.

The simple clutch ring *c* is not very desirable, as its sharp corners cut into the rod *D*, and in time roughen it up, nevertheless it was used for many years with

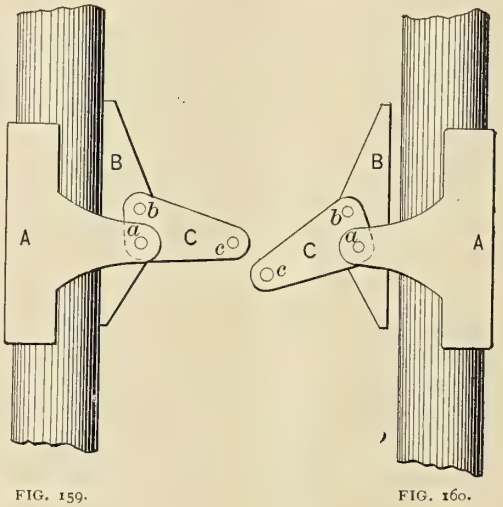


FIG. 159.

FIG. 160.

the most successful of lamps. At the present time there are many modified forms of clutching devices, one of the simplest and most effective being shown in Figs. 159 and 160, the first showing the clamp when hugging the rod, and the second one when in the release position. As can be plainly seen, the shoe *B* is

forced up to the rod by lifting the outer end *c* of lever *C*, thus giving a powerful grip between *A* and *B*.

Arc lamps can be operated from incandescent light circuits, and in some cases they are arranged so that two are burned in series, while in others they are used singly Ordinary arc lamps require an E.M.F. of about

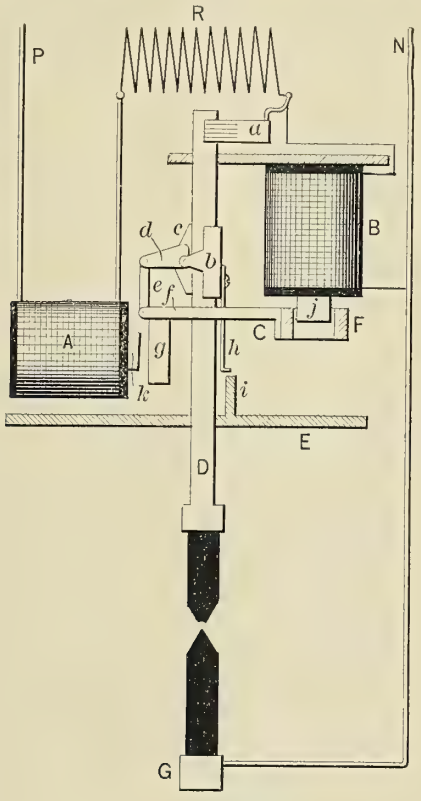


FIG. 161.

45 volts, so that if two lamps are connected in series in an incandescent circuit of 110 volts, each one will operate under an E. M. F. of 55 volts, unless a resistance is introduced to balance a part of the pressure. When a single lamp is connected across an incandescent light circuit, it is arranged to operate with an E.M.F. of between 80 and 90 volts, and a resistance is introduced to balance the remainder of the voltage. Lamps can operate upon incandescent light circuits whether made with one magnet, as in Fig. 157, or with two, as in Fig. 158. Fig. 161 illustrates diagrammatically the Brush lamp as used on incandescent light circuits. Its operation is as follows: When the light is turned off, the carbons do not touch, but are separated, as in the cut. When the current is turned on, it passes through magnet *A* and a resistance *R* and from here goes to a magnet *B* and thus to the opposite side of the line without passing through the carbons. This starting current is very weak, as it is held back by the high resistance of magnet *B*, which is wound with very fine wire. Magnet *A* is wound with large wire, therefore, the magnetism developed in it by the starting current is next to nothing, but magnet *B* becomes very strong on account of being wound with many thousand turns of fine wire. On this account *B* pulls up the armature *F* on the end of lever *C*, and as this lever is pivoted at *f*, the connecting rod *e* is drawn down and with it the clutch *c b*, which is of the type illustrated in Figs. 159 and 160. By the descent of the clutch the extension rod *h* is brought into contact with stop *i* and then the clutch opens and allows the rod *D* to slide through until the carbons come in contact. When this occurs, the current through magnet *A* at once becomes strong, for all the current that passes through the carbons passes first through magnet *A*, thence through resistance *R*, and then by way of contact *a* to rod *D*. As soon as *A* becomes strong, its pole *k* attracts armature *g* and thus the clutch *c b* is raised and with it the rod *D* and the upper carbon. The two magnets *A* and *B* are so adjusted in strength that springs are not required, there being simply a tug of war, so to speak, between the two. When the current becomes too strong, *A* predominates and lifts the clutch, and when the current becomes too weak *B* predominates and lowers the clutch. In order to prevent the movement of the lever *C* from being too violent, a dash pot is provided.

Nearly all the arc lamps used on incandescent light circuits are provided with a small globe that encloses the arc, and they are known on that account as enclosed arc lamps. The advantage of this type of lamp is that the carbons last from ten to fifteen times as long as in the open arc lamps, the greater length of life being due to the fact that the globe excludes the air and thus prevents the consumption of the carbon by actual combustion.

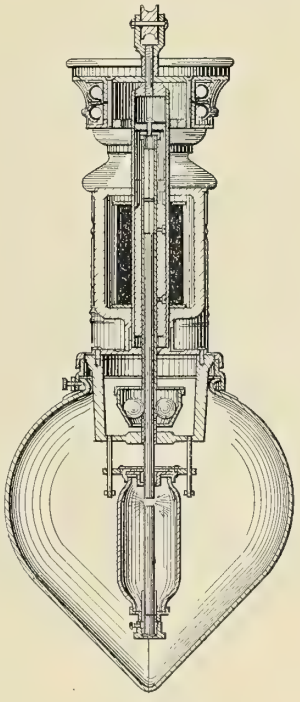


FIG. 162.

Some of the enclosed arc lamps have the mechanism so arranged that the rod *D* of Fig. 161 is not required, the clutch acting directly upon the upper carbon rod it-

self. By using this construction the length of the lamp is considerably reduced. Fig. 162 shows a lamp of this type. The clutch consists of a number of marbles, which are carried in a short conical tube. When this tube descends far enough, the marbles strike the upper end of a tube through which the carbon rod passes, and are thus drawn away from the latter, and allow it to slip through. The conical tube that carries the marbles is raised and lowered by the action of a magnet coil which is shown in section in the cylindrical portion of the lamp, just above the top of the outer globe. In the upper part of the lamp a resistance is located which is used to balance the excess of voltage.

RECENT LITERATURE.

OLD OCEAN'S FERRY. Compiled by John Colgate Hoyt, 1900. Published by Bonnell, Silver & Co., New York. Size 7 3-4 by 5 in. Pages 266. Cloth, 50 cents.

To quote from the subtitle, this book is "a collection of odd and useful information for nautical travel, and strange features of the sea for landsman and mariner." The average landsman in making his first ocean voyage finds himself in a new world. The conditions of life are completely changed, everything is strange and new, and if of an observant nature he finds a thousand questions presenting themselves regarding his new environment. It is to furnish an answer to some of these questions that this little volume has apparently been written. It is, of course, a compilation with bits of information drawn here and there from the entire realm of the sea and nautical affairs. Only the index itself could serve to give a comprehensive idea of the ground covered. Some of the more important subdivisions, however, will give a general idea of the nature of the contents. Such are: Historical; Navigation for passengers; Ship and steamship records; Tables and information useful on shipboard; Commerce and shipping; Hydrographical; Sea life; Ancient and modern navies; Nautical notes; etc., etc.,

A few paragraph headings selected at random will serve to give a further idea of the range of topics treated. Such are: A brief nautical vocabulary; The latest theories and treatment for seasickness; Extracts from the U. S. customs laws and tariff schedules; Foreign mails; Cable rates to various parts of the world; Rules of the road at sea; Funnel marks, house flags, and night signals of the transatlantic lines; Signals at sea; Rules for hurricanes; Names of parts of a full-rigged ship; useful hints to passengers on ocean steamers; A collection of nautical conundrums, etc., etc.

The information given seems in general to have been chosen with good judgment, and to have been brought well down to date. The author can hardly have hoped to supply answers to all topics on which landsmen are liable to want information, but he has certainly made a long stride in that direction. There is also a large amount of information which will be found of great interest and value to those familiar with nautical affairs. As a whole this little book may properly claim to have been written in answer to a "long felt want," and it may be cordially recommended to all those about to take a sea voyage, or who may be interested in nautical matters.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—Would you kindly decide on a disagreement of opinion regarding a fusible plug? A says a fusible plug will blow out of a boiler that has not been cleaned in three months. B says that it will not blow out only in case you lose track of the water. Have you ever heard of a case where a fusible plug blew out otherwise than by losing water?

A.—A fusible plug blows out because it melts; it melts because it becomes heated to its melting point; and it becomes thus heated because it receives more heat on one side than can escape on the other. The heat thus becomes banked up in the plug, so to speak, until the melting point is reached. Any condition, therefore, which will prevent the escape of heat from the water side of the plug while it is receiving heat on the fire side will result in the melting of the plug. Such a condition exists when the water falls below the level of the plug, leaving it in contact with steam only on one side and fire on the other. This is the usual cause of the melting of a plug, and is the condition which the melting is intended to indicate. There are other causes, however, which may prevent the escape of heat on the water side, and which may also lead to the melting of the plug. A sufficient layer of boiler scale might give rise to this condition, though such a result can hardly be expected from the usual type of plain scale. A layer of oil or grease, however, or of mixed scale and oil, is a very poor conductor of heat indeed, and experiments have shown that such a covering on the water side is quite sufficient to prevent the escape of heat and to lead to the melting of the plug, even though the level of the water is well above the plug itself.

NEW FREIGHT LINE ON LONG ISLAND SOUND.—The establishment of a new line of freight steamers between New Haven, Bridgeport, New York and Philadelphia is announced. The company which is back of the new system is the New York & Baltimore Transportation Co., of Baltimore, which is capitalized at a million dollars, and owns a fleet of many freight and passenger steamers.

The annual report of the American Shipbuilding Co. which controls practically all of the shipyards on the great lakes shows that it has turned out twenty-nine vessels during the past fiscal year with a carrying capacity of 17,000 net tons, and that sixteen vessels are now under construction. The net earnings of the company are also shown to be $1,100,665.85. After deducting $532,000 for a 7 per cent. dividend on the 7,600,000 of preferred stock, there remains $568,665.85, amounting to 7.48 per cent. on the $7,600,000 common stock. This is a most gratifying showing for the year, and is evidence both of the thriving condition of shipbuilding on the lakes, and of the excellent management of the affairs of the company for the year.

According to the returns from the Commissioner of Navigation one hundred and five vessels aggregating 35,944 gross tons were built in the United States, and officially numbered during the month of July.